Enriching the Neolithic: The Forgotten People of the Barrows.

Submitted by Gillian Sarah Cuthbert to the University of Exeter as a thesis for the degree of Doctor of Philosophy in Archaeology

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I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

Signature: …………………………………………………………

Abstract

This detailed study involved the osteological examination of over 36000 human bone specimens (the majority of which were highly fragmented) representing a minimum of 305 individuals from 42 Neolithic sites, and is the most up-to-date synthesis on the health, lives and demography of the people from southern Britain. The aim of the project was to analyse the collections excavated in antiquity which had never been examined by an osteologist, or to re-examine those that have not benefitted from modern techniques, with the intention of collecting demographic data, recording palaeopathology, stature and any dietary deficiencies that affect the skeleton. The importance of re-analysing previously examined collections was particularly illustrated by the extensive assemblage from Hazleton North long barrow, which comprised over 21500 fragmented and whole bones. This site had evidence of multiple funerary behaviour in the form of inhumation, cremation, and excarnation, a practice that was previously unrecognised at the site. Important discoveries were made in the field of palaeopathology – 67% (4/6) of those affected by Vitamin C deficiency in this study were excavated from the site, together with one case each of suspected poliomyelitis, DISH, septic arthritis, and high prevalence rates of dental and joint diseases. The re-examination of extant Neolithic collections also revealed new evidence of infectious disease, in the form of six cases of otitis media and one of meningitis; metastatic cancer in a child; metabolic disorders, including scurvy and rickets; various congenital disorders including muscular torticollis; and 12 likely cases of trauma caused by inter-personal violence; together with a comprehensive evaluation of non-specific indicators of stress in the population. The project stresses that even very fragmented and disarticulated collections of human bone can reveal a wealth of information about the people who underwent a major shift in subsistence practices, culture and worldview, which can only add value to the archaeological record of such an important time in prehistory.

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A DVD is attached to the back inside cover of the thesis, containing the Excel spreadsheets from each site studied.

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Chapter 1: Introduction

1.1: Introduction

The Neolithic period heralded an era of transformation and had a fundamental impact on the development of human interactions, behaviour, and beliefs (Bradley 2007: 29; Cummings 2002: 107; Meillassoux 1972; Whittle 1996: 8). The term “Neolithic” was devised in antiquity and describes “the later or polished Stone Age; a period characterized by beautiful weapons and instruments made of flint and other kinds of stone” (Lubbock 1865: 2). But the period was much more impactive than merely producing a progression in stone technology, with the inhabitants of this significant period in prehistory experiencing unparalled development in social relations, culture, and tradition (Smith and Brickley 2009: 9). . A wave of migration by Anatolian farmers from continental Europe introduced innovative subsistence practices, a new social organisation and economy, diverse material culture, and inevitably, health and disease vulnerabilities (Brace *et al.* 2018: 2). This period of enormous change was unprecedented, and Smith (2002: 181) states that the extensive adoption of food production was the most significant episode in human history until the Industrial Revolution. The introduction of a new population and ideas ultimately altered the attitudes and behaviour of the inhabitants of what was to become Britain, ushering in a new approach of interaction with the landscape, and indeed each other, which culminated in the construction of monuments, the majority of which contained the bodies of what would seem to be carefully selected individuals. Crucially, what distinguishes the Neolithic period from those preceding it, is the treatment of the body following death.

There is scant evidence for human burials from the Palaeolithic and Mesolithic periods in Britain, but where it does exist, the inhumations have been excavated from within caves (Barton 2006: 22; Meiklejohn *et al*. 2011: 22-36). However, the recent discovery of a small cemetery which contained five burials dating to the Mesolithic period, has been uncovered on a small island on the floodplain of Somerset (Brunning and Firth 2012: 21). Aveline’s Hole, a Mesolithic cave site in Somerset, held the bodies of up to 50 individuals, which had been placed on the floor of the cave, and which lay undisturbed until their discovery in the 18th century (Schulting 2005: 243; Meiklejohn *et al*. 2011: 22). This funerary behaviour is in direct contrast to the rituals practiced in the Neolithic period. Not only were enormous monuments constructed to hold burials (although there a few examples of long barrows without any inhumations) but the living seemed to have an almost intimate relationship with the bones of the deceased. Very few articulated skeletons have been excavated from sites, instead the bones of the dead had been manipulated, sorted, removed, or stacked (Beckett and Robb 2006: 60; Leach 2008: 42; Reilly 2003: 137). Whilst the handling of the human remains in the past has added to the fragmentation and in some cases, limited the survival of the assemblages, placing the dead in conspicuous monuments has facilitated the discovery and retrieval of the bones, enabling osteological analysis on a far greater scale than was possible for preceding periods. These individuals, who experienced unprecedented changes to their lifeways and worldview are the focus of this study. They would have been at the forefront of the transition between the hunter-gathering way of life, to a more settled existence with the introduction of domesticated animals and cereals, a change that would have a dramatic effect on their everyday lives and health. An up to date examination of who was interred within these impressive monuments may help identify what attributes were considered significant for inclusion within the tomb, and whether these individuals were representative of the community as a whole.

1.2: Aims and Objectives

Recently, it has been noted that although over 137 Neolithic sites have been excavated and published, the human remains that were recovered have not been reported on by trained osteologists (Beckett and Robb 2006: 60). Furthermore, Smith and Brickley (2009: 148) recognise the need for re-analysis of assemblages that were excavated and described in antiquity, as they may hold evidence of diseases that were not recognised at the time. In consequence, there was a real need to examine the collections which have either never been analysed by an osteologist, or have been examined in the past, but without the benefit of modern techniques. By examining the extant collections of available skeletal material, it may be possible to infer how the health and diet of the population was affected through time.

The main research objectives were as follows:

- Obtain demographic data (age, sex, mortality analysis) from each tomb to begin to reconstruct bioarchaeological profiles.
- Record details of paleopathology.

- Assess the health of the population by recording stature and any dietary deficiencies that affects the skeleton.

The scope of the current study was to locate the excavated human remains from as many Neolithic long barrows from southern Britain as possible within the time allowed. The details of this endeavour are given in Chapter 2 and Appendix 1, with full details of each site, burial type and number, date of construction (where new dates were available), and date of excavation in Appendix 2. In consequence, it was possible to analyse inhumations and cremation burials from 42 sites, ranging from Lincolnshire, to Devon (Figure 1) with the sites from the Cotswolds in detail in Figure 2.

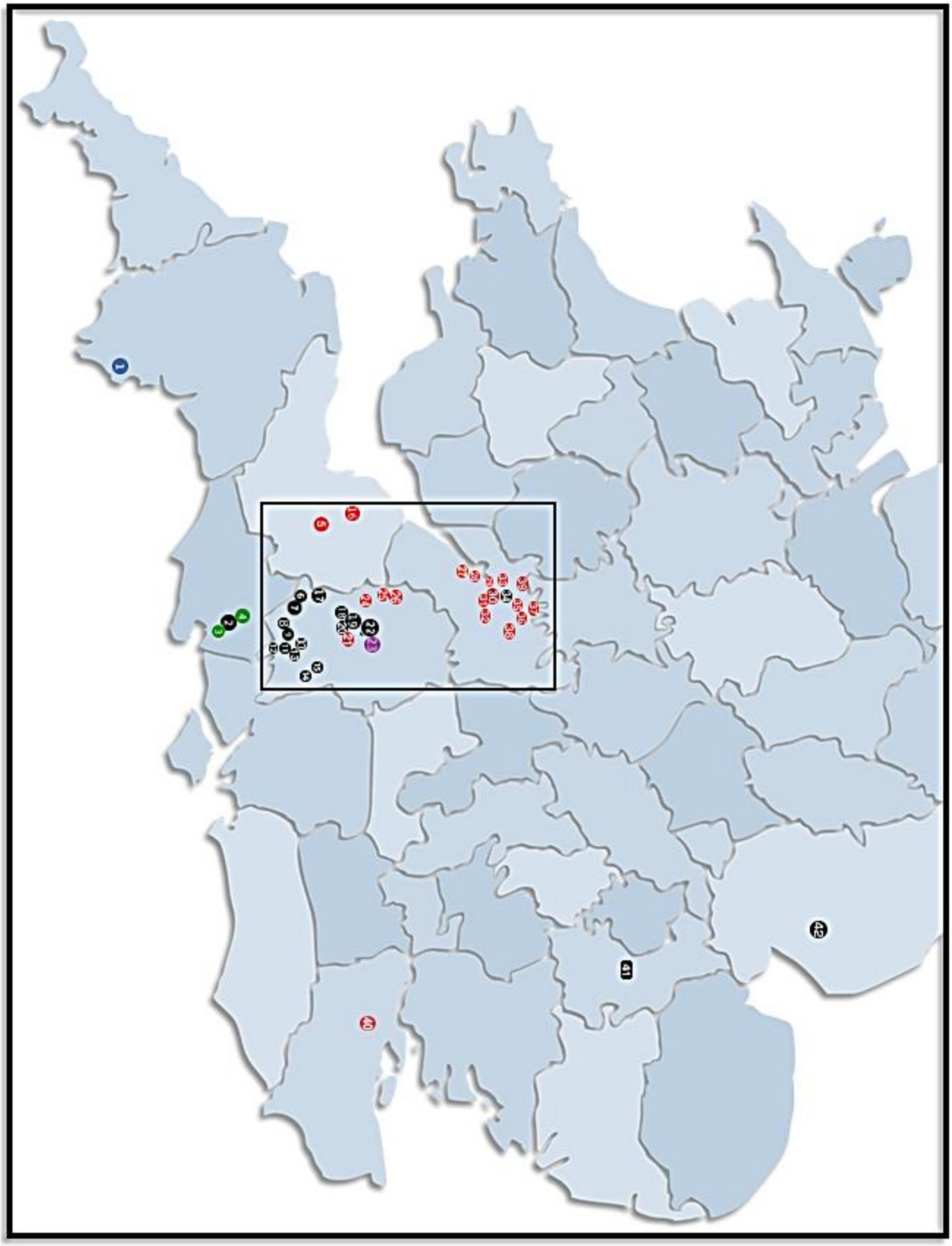
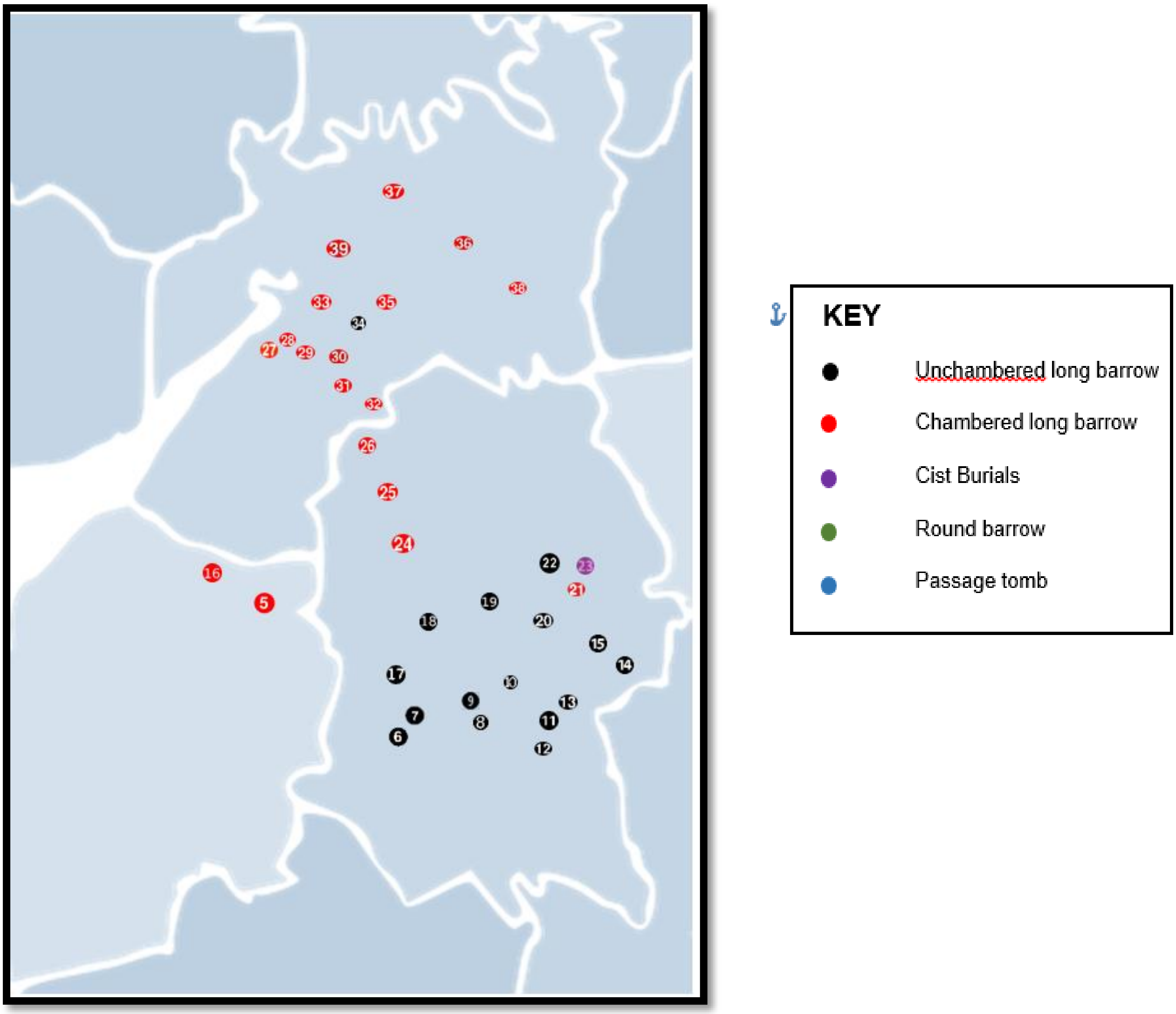


Figure 1.1: Map of sites in the current study, with key and detailed map of those sites in the black box overleaf.



1. Broadsands 2. Wor Barrow 3. Handley 26 4. Handley 27 5. Fromefield 6. Norton Bavant 7. Bowl's Barrow (Imber) 8. Tilshead Old Ditch 9. Tilshead Lodge 10. Tilshead East 11. Figheldean Down (31) 12. Stonehenge (Amesbury 14) 13. Netheravon Down 14. Fittleton Down 15. Fyfield (Giants Grave) 16. Stoney Littleton 17. Bratton Camp 18. Kings Playdown 19. Oldbury Hill 20. Horton Down (Bishops Cannings 91) 21.West Kennet 22. Millbarrow 23. Winterbourne Monkton 24. Lanhill 25. Littleton Drew (Lugbury) 26. Luckington (Giants Cave) 27. Hetty Pegler's Tump (Uley) 28. Nympsfield 29. Bown Hill (Woodchester) 30.Gatcombe Lodge 31. Avening 32. Rodmarton 33. Randwick 34. Avenis (Smart's Farm) 35. Jackbarrow 36. Hazleton North 37. Belas Knap 38. Lamborough Banks (Ablington) 39. West Tump (Cranham) 40. Chestnuts (Addington) 41. Haddenham 42. Giants Hills (Skendleby I).

Figure 1.2: Map of sites within the Cotswolds in detail (copyright: Digimap 2018).

Following the examination of every fragment of bone from the sites available, the research questions below were posed:

- Does the re-examination of human skeletal material from the Neolithic period provide insights into burial rites and either confirm current knowledge, or contradict it?
- Do the demographic profiles of those interred within the tombs add insights into who was selected for specific funerary rituals?
- Does examination of the bones allow inferences to be made about the health and diet of the population?
- Can the patterns of traumatic injuries to bone add to the growing corpus of knowledge on an increasing propensity for violence in the Neolithic period?

Having posed these questions, consideration was given to any possible selection bias in those individuals chosen to be interred within the monuments, and what significance this preferential treatment may have had in relation to the beliefs of the community.

1.3: Layout of the Thesis

Chapter 2 is in two parts: the first section deals with the history of research into the Neolithic period from the Renaissance to modern times, with a breakdown of the sites from which Neolithic human material has been reported to have been excavated; the second section discusses Neolithic human remains from an osteological perspective, and details the pioneering work of numerous individuals interested in the field. Chapter 3 is concerned with Neolithic burial practices, including primary and secondary burials, and cremation. The chapter ends with a discussion of the longevity of long barrow use, a topic that has recently been challenged by a new dating programme. The following chapter, Chapter 4 deals with the difficulties of locating the whereabouts of the identified assemblages, and the reasons for this. In addition, the methods used to analyse the human remains are separated into those used for inhumation and cremation burials. Chapter 5 is concerned with the physical characteristics of the assemblages, including an extended section on important new evidence of excarnation. The following eight chapters are concerned with the pathology evident on the human skeletal material. Chapter 6 discusses the metabolic diseases that were observed in the collection, including new evidence of scurvy at sites, rickets, osteoporosis, and non-specific indicators of stress, including cribra orbitalia and porotic hyperostosis. Chapter 7 sets out the infectious disease evident in the collection, including osteomyelitis, periosteal new bone formation, and new evidence of several cases of otitis media, meningitis and possible poliomyelitis. Chapter 8 is concerned with joint disease, with most of the joints in the human body having evidence of osteoarthritis, plus one case each of DISH, ankylosing spondylitis, and septic arthritis. Additionally, the chapter includes a section on degenerative conditions of the vertebral column. Chapter 9 concentrates on dental disease, reporting on carious lesions, dental abscesses, periodontal disease, calculus, ante-mortem tooth loss, enamel hyperplasia, plus additional dental anomalies. The following chapter, Chapter 10 outlines the traumatic injuries that were inflicted upon the individuals in this study, including one new case of peri-mortem cranial trauma, and three cases of healed cranial trauma. Additionally, fractures are detailed by element affected, together with information about soft tissue injuries and three cases of trepanation. Chapter 11 discusses the congenital and developmental defects observed in this study, some of which would have been asymptomatic. However, one individual would appear to have an unidentified syndrome and five others had congenital and developmental disorders which would have had an aesthetic and physical impact on their everyday lives. Chapter 12 is concerned with circulatory disorders, and in all cases, was in the form of osteochondritis dissecans, affecting six individuals from three different sites. The last chapter on pathology details the evidence of neoplastic disease, which in most cases were benign. However, one compelling case of metastatic cancer in a child is discussed. In Chapter 14 the research questions will be returned to, drawing the information gleaned from this detailed study in the discussion. Finally, the last chapter, sets out the conclusions and suggests avenues for further research.

Chapter 2: History of Research

2.1 Neolithic Literature Review

Despite an enduring scholarly interest in the Neolithic, very little is known about the people who were at the forefront of the transition from a hunter-gathering past to a settled and agricultural way of life. This major shift not only necessitated a new world view, which had a profound effect on belief systems, but altered the way in which humans interacted with the landscape. This in turn had a dramatic effect on their everyday lives and health. By embarking on an exhaustive study of the skeletal human remains from the Neolithic period, a picture of how this transition affected the inhabitants may emerge.

The current study intended to make a comprehensive analysis of all the available skeletal human remains from Neolithic tombs from southern Britain. This research addressed a substantial knowledge gap of what is currently known about the people from this period. The National Monuments Record lists 538 long barrows in England and two recent studies by Beckett and Robb (2006) and Smith and Brickley (2009) have stressed the need for more detailed study of human remains from this period. These authors have noted that over 137 tombs with human remains from all over Britain have been excavated from this period but very few have been analysed by a trained osteologist. Following an extensive examination of the archaeological records held at county level (the Historic Environment Record), it was ascertained that of the 296 possible, and 459 definite long barrows in southern Britain, 120 monuments contained human remains. These sites became the focus of this project.

This literature review of the Neolithic period and the human population who shaped it will be broken down into two parts – a review of Neolithic studies in general, encompassing an overview of the increasing interest in the human past during the Renaissance, and the specific sites to be analysed in this study.

Scholarly interest in the antiquities of Britain did not really begin to take hold until the 16th century, following new interest in the human past during the Renaissance (Piggott 1989: 8). However, mysterious monuments were sometimes referred to in historical documents, such as an illustration of Merlin building Stonehenge, from a 14th century manuscript of Wace's *Roman de Brut* (Trigger 1989: 32). In addition, the description of the dragon's lair in the epic poem *Beowulf,* written in the eighth century, was interpreted by Thurnam (1869: 202) to characterize the chambers found within megalithic long barrows.

The first scholar to record the antiquities of Britain was Leland, who was commissioned by Henry VIII in 1533 to travel around the land, recording the details of old documents, old buildings and monuments in his notebooks, later called his *Itinerary* (unpublished) (Piggott 1989: 14). During his tour, which lasted from 1534 to 1543, Leland described the landscape and the monuments within it, but on at least one occasion ventured within a tomb, observing that it was constructed with chambers and contained the bones of many individuals (Toulmin- Smith 1964: 102). Despite never being published, Leland's *Itinerary* founded a new interest in the antiquity of man, a path well-trodden by his successors (Marsden 1984: 1).

The second antiquarian of note was Camden, who utilised much of the information in Leland's unpublished work to augment his lengthy tome on the antiquities of Britain, *Britannia,* published in Latin in 1585 (Piggott 1989: 18). In fact, such was the popularity of Camden's work, it was updated and several editions produced up to 200 years after his death in 1623, laying the foundations for the County Histories written in the 19th century (Piggott 1985: 18).

The first antiquarian to take a more scientific approach to the recording and classification of monuments was Aubrey, a 17th century squire from Wiltshire (Powell 1948: 27). He was the first scholar to write a book consisting purely of archaeological material, chiefly centred on the landscapes of Avebury and Stonehenge but also included other types of monuments, such as barrows (Powell 1948: 287). This great work took over 30 years to complete and was titled, *Monumenta Britannica*. Unfortunately, Aubrey's manuscript was never published in his lifetime and was in fact, only recently published in its entirety in the early 1980s (Aubrey 1982).

Aubrey's contribution to the foundation of Archaeology as a subject of serious study cannot be underestimated. Whilst he understood that the ancient monuments that he had carefully surveyed were pre-Roman, he had no notion of *prehistory*. This was based on Aubrey's observation that there were an abundance of monuments in places such as Ireland that had never been invaded by the Romans (Sweet 2004: 125). In *Monumenta Britannica* Aubrey says "The Romans had no dominion in Ireland or in Scotland at least not far: therefore these Temples are not to be supposed to be built by them .... all these monuments are of the same fashion, and antique rudeness: wherefore I conclude, that they were erected by the Britons: and were Temples of the Druids" (Piggott 1989: 115). Aubrey correctly deduced that megalithic monuments were older than the Romans; it is just unfortunate that he assigned their construction to the Druids. He was using classical texts, such as writings by Caesar and Tacitus, to interpret them (Daniel 1981: 29).

Following in Aubrey's footsteps, and very much influenced by him was a scholar called Stukeley, who was the author of a great amount of literature but is chiefly associated with three great works - *Itinerarium Curiosum* was published in 1724, *Stonehenge* in 1740, and *Abury* in 1743 (Piggott 1989: 33). Right from the beginning, Stukeley wanted to make his archaeological intentions clear. He states in the preface of *Itinerarium Curiosum* that he intends to give "an account of places and things from inspection, not complete from other's labours, or travels in one's study" (Evans 1956: 75).

Itinerarium Curiosum detailed the tours that Stukeley had undertaken during the years 1710 to 1725. He travelled the length and breadth of Britain, visiting and recording sites such as churches and cathedrals and latterly, recording features in the prehistoric landscape, including stone circles, barrows and earthworks. During the tours, which extended from the southern coast of Britain right up to Hadrian's Wall, Stukeley made very clear and accurate drawings of every site that he visited (Piggott 1985: 36). In fact, due to Stukeley's keen observations and fine draughtsmanship, archaeologists today are able to use his work to view the landscape in a bygone age. There are many instances where Stukeley recorded monuments that up until recently, were no longer visible, such as the Beckhampton Avenue. The idea that Avebury had two avenues (the other being the West Kennet Avenue) running from it, was considered nonsense (Piggott, 1985). However, in 1999 archaeologists rediscovered the Beckhampton Avenue during excavations (Gillings *et al*. 2008: 6), therefore confirming Stukeley's reputation as an "honest and reliable "fieldworker (Mortimer 2003: 1).

The assumption that digging into long barrows only commenced during the 19th century is not strictly true. There are many examples of later burials being inserted into Neolithic long barrows, perpetuating the use of these sacred sites. In Dorset, Thickthorn Down long barrow does not contain any primary burials, but four skeletons in flexed positions were excavated from the centre, accompanied by Beaker pottery, and one with a bronze awl (Drew and Piggott 1936: 80). In addition, the long barrow within Maiden Castle, excavated by Mortimer Wheeler in the 1940s, was thought to contain Neolithic human remains, which have subsequently been dated to the Anglo-Saxon period (Brothwell 1971: 240).

In Oxfordshire, the long barrow on Whitehorse Hill not only contains a Bronze Age cremation, but became the focus of a Romano-British cemetery containing 46 skeletons, five of which had a coin placed in their mouth (Oxfordshire HER and Oxford UAD, 2014). In Wiltshire, two long barrows were found to have multiple Anglo-Saxon burials inserted into the mounds, with two other long barrows having a single Anglo-Saxon secondary burial (Wiltshire and Swindon HER, 2014).

However, it was not until the 18th century that the excavation of long barrows became a popular pastime for the landed gentry. Colt Hoare was born into a banking family and inherited large estates in Wiltshire from his grandfather, allowing him to pursue an interest in the ancient landscape in which he now lived (Sandell 1961: 1). Having met Cunnington in 1803, Hoare "became infected with the mania of antiquarianism" (Marsden 1984: 16). Together, they embarked on a large scale programme of the excavation of burial monuments, with Cunnington as the excavator of the 465 (round and long) barrows, Crocker enlisted as a surveyor, and Hoare as the patron (Piggott 1989: 155). The aim of this extensive intrusion into the landscape was an honourable attempt to gather *the facts* about the human past, not wild speculation as to former inhabitants of the land "we speak from facts, not theory" (Colt Hoare 1812: 7).

The partnership produced accurate and detailed plans of the landscape which were included in the two large volumes written by Colt Hoare, *The Ancient History of Wiltshire* (1812). Unfortunately, there are no site plans or drawings of the barrows excavated. Moreover, the details of the human remains encountered from the tombs are very vague and uninformative. Burials are only discussed in their orientation and of being a cremation or inhumation, "we discovered seven or eight skeletons lying in every direction; the thigh bones of one by the head of another, a skull on the breast of a second, etc. etc., but no trinkets or warlike or domestic instruments" (Colt Hoare 1812: 54). Indeed, the treatment of the human remains from the excavations was not only unscientific but in some cases, destructive and disrespectful. Despite stating in the introduction of *Ancient Wiltshire* that all human remains would be carefully reinterred within the tomb from which they came, it seems the group noted how well the bones were preserved because “they could be thrown for a considerable distance without breaking” (Colt Hoare 1812: 163).

Fortunately, during the 1850s Thurnam, a medical doctor from Wiltshire, re-opened many of the barrows that had been dug by Colt Hoare and Cunnington, this time, retaining the human remains (Marsden 1999: 86; Thurnam 1854; Thurnam 1857a; Thurnam 1857b; Thurnam 1860a; Thurnam 1860b). In fact, Thurnam’s main reason for excavating these monuments was to retrieve the human skeletal material, and did not consider the result as *successful* unless the bones were found and removed (Thurnam 1869: 179). To this aim, Thurnam opened 21 unchambered long barrows in Wiltshire, and 27 chambered long barrows in Wiltshire, Berkshire, Gloucestershire, and Somerset. From these investigations, nine excavations from the unchambered type of tomb (a distinction noted by Thurnam) and 14 from the chambered tombs were deemed successful (Thurnam 1869: 180).

Thurnam published his findings and other important musings on the subject of long barrows in *Archaeologia* in 1869. This work detailed every published report on excavations to date, a discussion on types of tomb, and most importantly, details of the burials. He included measurements of some long bones, giving an estimate of stature and detailed several crania. Indeed, the study of human crania had long been an interest to Thurnam, who published papers on the subject in 1864, 1865 and 1867, and who authored *Crania Britannica* with Barnard Davis in 1865. This book detailed the measurements and shapes of prehistoric, Roman and Anglo-Saxon skulls.

However, despite Thurnam’s excellent detailed recording of the human remains from long barrows, his excavation methods had not really improved from Colt Hoare and Cunnington’s time. Like them, his approach to excavation was by digging a large hole in the top of the barrow and to continue down until the original floor surface was reached, hopefully with a pile of bones or single burials present. In this way, he may have missed many other burials in other parts of the tomb, a scenario witnessed at West Kennet where he only excavated the west chamber (Marsden 1999: 89). Nevertheless, Thurnam’s approach to the detailed recovery of human remains from archaeological sites, together with his monograph on long barrows must be commended.

Contemporaries of Thurnam's who also had an impact on the archaeological record in the form of barrow digging were: Mortimer, Bateman, and Greenwell in the north of England (the latter also opening three long barrows in Gloucestershire on his own, and three others with Royce or Rolleston) (Greenwell and Rolleston, 1877), these three excavators opening 801 barrows between them; in the south of Britain, Borlase in Cornwall; Warne in Dorset; Witts in Gloucestershire; Merewether and Lukis in Wiltshire; and Skinner in Somerset.

During the latter part of the 19th century one figure stands out for his contribution to the practice of archaeology. Lieutenant-General Pitt Rivers, a former pupil of Greenwell, inherited the Rushmore estates, centred on 27000 acres of land on Cranborne Chase, Dorset (Green 2000: 29). Pitt Rivers produced four large volumes of work, detailing the excavations on his land (Pitt Rivers, 1887-1898). He introduced a scientific way of removing a barrow, section by section. During this process, the exact location of every find was noted and detailed plans were drawn, including section plans and contour maps. His most famous excavation, Wor Barrow, a long barrow on Handley Down, was excavated in 1894. The record of the excavation includes 30 pages of text, five plans and sections, five pages of photographs, 14 plates of finds, seven pages of artefact tables, and details of human and faunal remains (Marsden 1999: 151). Moreover, this methodology set the standard for all successive investigations and can still be said to parallel modern techniques. Furthermore, the inclusion of a separate bone report in subsequent investigations would seem to have been influenced by the careful and thorough work by Pitt Rivers (Smith and Brickley 2009: 34).

At the beginning of the 20th century, one of the most influential scholars in Neolithic studies was Gordon Childe, who initiated the debate on why change occurred in the Neolithic period. In his ground breaking book *The Dawn of European Civilisation* (1925), Gordon Childe proposed that instead of a single people migrating across Europe from the west, settling in Britain and building megalithic monuments, it was the *idea* that spread. It was known that as long ago as 3200BC, people were being buried within tombs in Crete. Therefore, Gordon Childe proposed that knowledge was spread from Crete to Spain, thence onto the rest of Western Europe via trade routes. In fact, this view held sway until the 1950s when the use of radiocarbon dating began. When the British tombs were dated using this method, it was found that they were, in fact, older than those of Crete, and so Gordon Childe's diffusionist ideas were dismissed (Renfrew 1974: 56).

In the same year that Gordon Childe published *The Dawn of European Civilisation,* an Ordnance Survey Archaeological Officer called Crawford published *The Long Barrows of the Cotswolds*. This work detailed all of the long barrows in the Cotswold area, some of which did not appear on Ordnance Survey maps, and gave details about their position, purpose, age and structure and previous excavations, and remains today one of the most comprehensive volumes regarding Neolithic monuments (Darvill 2010: 28).

Following the end of the war, several prominent scholars published important works on the Neolithic period. Piggott published *Neolithic Cultures of the British Isles* (1954) and *The West Kennet Long Barrow, Excavations 1955-1956* (1962*),* having already published important articles on Neolithic pottery (1931) and the chronology of English long barrows (1935), in which Piggott went against the grain of current thinking and proposed that earthen long barrows were older than megalithic long barrows. Piggott was a prolific excavator, digging many prehistoric sites in Wessex including, Thickthorn long barrow (Drew and Piggott, 1936), Lanhill long barrow (Keiller and Piggott, 1938), Stonehenge (Cleal *et al.* - report not published until 1995), Wayland's Smithy (Atkinson, 1965), and seven sites in Scotland, including the excavation of the Dalladies long barrow in Kincardineshire (Piggott, 1972). In later years, having held many distinguishing public positions, among them as President of the Prehistoric Society and Vice President of the Society of Antiquaries of London, Piggott published *William Stukeley: an Eighteenth Century Antiquary* (1985), followed shortly by *Ancient Britons and the Antiquarian Imagination: Ideas From the Renaissance to the Regency* (1989). Ultimately, Piggott's contribution to archaeology may be summed up by Bradley (*British Archaeology*, 1996), who says, "more than anyone else [he] laid the foundations for the study of British prehistory and ... taught most of the senior figures in the discipline today."

Daniel published *The Prehistoric Chamber Tombs of England and Wales* (1950) and *The Megalithic Builders of Western Europe* (1958) and was the first scholar to title the megalithic tombs of the north Wessex Downs, south of the River Avon, West of the River Severn and the Cotswolds, the Cotswold-Severn Group (Daniel 1937: 186). Daniel's lifelong interest in Neolithic chambered tombs led him to build on the classification of the monuments by Montelius and to draw links with the megalithic tombs of Europe, at the same time debating their development and distribution (Daniel, 1939). As a fieldworker, Daniel assisted in an excavation at the megalithic tomb of Bryn Yr Hen Bobl in his native Wales (Hemp, 1936) and in southern Britain at Notgrove long barrow (Clifford, 1936), Nympsfield long barrow (Clifford, 1938) and at Rodmarton (Clifford, 1940).

Grinsell published many volumes on excavated sites in the Cotswold area, and compiled comprehensive surveys covered by this area, including *Dorset Barrows* (1959, 1982) and *Somerset Barrows* (1971); and Corcoran published a synthesis of the Cotswold-Severn tombs in *Megalithic Enquiries in the West of Britain* (1969).

Ashbee's excavation at Fussell's Lodge, Wiltshire, in 1957 gave rise to a very thorough report, consisting of 80 pages, and which was published in 1966. Unusually, this report gives a great deal of attention to the human remains recovered from the mound. The five groups of bones that were recovered are described, planned, photographed, and their positions noted with reference to each other, and in context with the rest of the mound. In addition, a 15 page bone report by Brothwell and Blake is the most comprehensive of its time, comprising demographic, metrical and pathological data. In 1960, Ashbee excavated Windmill Hill long barrow with Smith, and together with Evans, they excavated three long barrows near Avebury (Horslip, Beckhampton Road, and South Street) in 1979, and interestingly, none of these excavations uncovered human remains.

Ashbee published his seminal work, *The Earthen Long Barrow in Britain* in 1970, containing discussions of the structure, distributions, age, and artefacts found within long barrows, as well as a comprehensive chapter on the burials. The appendices also detail all of the burials (primary and secondary) found within long barrows in Britain, and remain a very useful source today.

During the next two decades, less emphasis was put on studying the burials within Neolithic tombs, and more on trying to explain their purpose. In 1976 Renfrew proposed that Neolithic long barrows were territorial markers, built by the dispersed but egalitarian community and which housed the bones of the ancestors, therefore legitimizing their ownership of the land. In *Understanding the Neolithic* (1999), Thomas argues that monuments, and the artefacts left behind by the inhabitants of this period, offered more than mere advances in technology and economics. Indeed, they were part of an important period of development within social relationships.

Kinnes's contribution to Neolithic studies are a wealth of publications but in particular, two volumes on monuments from this period. *Round Barrows and Ring-Ditches in the British Neolithic* (1979), brings together a register and synthesis of the largely ignored round barrows in Britain, which were considered by Thurnam to be of a Bronze Age date. *Non-Megalithic Long Barrows and Allied Structures in the British Neolithic* (1992) is a very informative volume covering a gazetteer of the monuments and summaries of the excavations. This is followed by discussions on form, distribution, structure, mortuary deposits and relationships with other traditions.

However, the complete excavation of Hazleton North long barrow by Saville between 1979 and 1982, was exceptional in its treatment of the recovery of human remains, and "provides one of the flagship analyses for Neolithic ritual Taphonomy" (Beckett and Robb 2006: 58), "carrying out the work to forensic standards" (Darvill 2010: 141). Saville's careful work plotted and recorded each piece of bone as it was unearthed to show element distribution and to allow for a re-fitting exercise in the future (Saville, 1990: 81; Beckett and Robb 2006: 58). The purpose of this type of analysis was to show patterns of fragmentation and in particular, to record how the different elements were moved around the tomb (Malone 2006: 110).

Woodward's *British Barrows: A Matter of Life and Death* (2000), is a concise volume which interprets the mass of data available about both Neolithic barrows, and those of the Bronze Age, whilst developing some new approaches to their study.

The last decade has seen the publication of two up-to-date volumes on Neolithic monuments. The first, by Darvill, is *Long Barrows of the Cotswolds and Surrounding Areas* (2010) which provides a modern perspective on this type of monument, together with details of the handful of excavations carried out within the last two decades. *Earthen Long Barrows: The Earliest Monuments in the British Isles* (2006) by Field, investigates the variety and complexity of earthen long barrows and how theories of their function have changed over the last 30 years. The book also reinterprets the burial evidence from Fussell's Lodge, and concludes that there were two distinct episodes of building at the site – a small burial area with axial pits and a surrounding ditch encompassing the mortuary enclosure, then the façade and trench were built with more pits and a forecourt.

Perhaps some of the most surprising aspects of the Neolithic period have emerged recently. The ground-breaking study by Bayliss and Whittle (2007) used Bayesian modelling and radio-carbon dates of five barrows from southern Britain to assess their dates of construction, use and abandonment. The surprising results showed that Ascott-under-Wychwood was built in about 3750 cal. BC, and the other four in 3650 cal. BC, and concluded that none of them were in use for very long, in fact, for only a few generations. This confounded the long-held idea that these monuments were in use for hundreds or even thousands of years. A further dating project of causewayed enclosures by Whittle *et al.* (2011) remodelled the chronology of the early Neolithic period in Britain, which contests the view that long barrows and causewayed enclosures were built contemporaneously. Settlements, cereals, and ceramics appeared first in south-east Britain at the beginning of the fourth millennium cal. BC, followed by domesticates, leaf-shaped arrowheads, ground axes, flint mines and long barrows in the next century, and lastly, causewayed enclosures and decorated ceramics appear by 3700 cal. BC. The spread of the Neolithic package appears next in south-central England, then slightly later in south-west England and Ireland, southern Scotland, and north-east Scotland, following the small-scale colonisation of people from continental Europe (Whittle *et al*. 2011: 833-847).

Bayesian modelling was also used by Allen *et al.* (2016) to re-evaluate the date of Wor Barrow on Cranborne Chase. The monument was originally thought to have been constructed in the later fourth century BC but the new approach indicated that the monument could now be firmly dated to the 37th century cal. BC (Allen *et al*. 2016: 16).

Schulting and Wysocki's (2005) study suggested that the Neolithic period was not as peaceful as once thought, also producing surprising results. Their work found that a significant proportion (between five and seven percent) of the crania studied from British sites showed signs of violent trauma. Some of the crania showed signs of healing, such as the individual from Fussell's Lodge, who had three healed fractures – one fracture may be due to an accident, but three are much less plausibly interpreted as such and would therefore appear to attest to deliberate acts of violence.

Lastly, in 2009, Smith and Brickley published *People of the Long Barrows: Life, Death, and Burial in the Earlier Neolithic,* an up-to-date and concise synthesis of the human remains found within the Cotswold-Severn type of monuments. The book interprets the available data from excavation reports and undertakes new analysis on assemblages from barrows at Notgrove, Adlestrop, Sale's Lot, Burn Ground and Bowls Barrow, in order to interpret the past lifeways of people in the Neolithic through skeletal analysis. This is achieved by a demographic appraisal of the different collections, together with assessment of health and diet and a consideration of Neolithic burial practices and taphonomic factors, and is the first synthesis since Thurnam, 140 years before, to consider and analyse the human remains found in Neolithic tombs and to interpret their important place within the period.

Recent research by The University of Reading has posed interesting questions about the purpose of long barrows in the Neolithic period, following the excavation of a monument in the Vale of Pewsey, Wiltshire in 2017. Cat's Brain long barrow is situated halfway between Stonehenge and Avebury, but the excavation did not produce the expected burials, but the remains of an enormous timber hall, leading the excavators to suggest that the purpose of the building was to consolidate a community identity, while providing a ceremonial meeting place for the living (theconverstion.com 2017).

2.1.1 Sites Reported to Contain Human Remains

One hundred and twenty sites have yielded Neolithic human remains from southern Britain (*N.B*. long barrows containing only secondary, and therefore, not Neolithic human remains, will not be included). For the current study, southern Britain was defined as from Lincolnshire in the east, across to Cheshire in the west, and all of the counties to the south. The long barrows are listed by county in Appendix 1 but greater detail is recorded in Appendix 2.

2.2 Osteological Literature Review

Any serious reconsideration of the people who experienced the most sweeping changes in worldview, subsistence and ideology in human history, by necessity needs to examine the role that osteological studies have played in firmly placing the inhabitants of the Neolithic in context. By analysing assemblages of human remains from archaeological sites, a picture may be built up of past people's lives, health, and sometimes, death.

The study of human remains from archaeological contexts had long been established in the United States of America but did not really begin to take on any semblance of significance in Britain until it was given credence by two medical doctors with an interest in archaeology. Together, Joseph Barnard Davies and John Thurnam published *Crania Britannica* in 1865, a study of prehistoric, Roman and Saxon skulls, which discussed the idea that racial affinities between groups could be evidenced through the shape of the skull (Davis and Thurnam, 1865). Thurnam advanced his theory in 1867 with a paper that proposed that the builders of two types of prehistoric barrows were built by two different races: long barrows were built by a race who featured long, or dolichocephalic skulls, and round barrows were constructed by people with round, or brachycephalous skulls (Thurnam, 1867). Indeed, Thurnam's ideas were so convincing, they held sway into the next century regarding the inhabitants of prehistoric Britain and influenced the work of Greenwell and Rolleston (1877), and others such as Parsons (1931), and Cave (1938b). However, despite Thurnam's dubious focus on the racial affinities of crania excavated from barrows, considerable effort was afforded by his followers to support such theories, by taking extensive measurements of recovered crania. Rolleston (1877) provided detailed drawings and 24 measurements of selected crania, whereas Parsons (1924) went even further and provided an astounding 117 measurements for each of 30 crania.

Regardless of the merits of Thurnam's observations, the focus of attention on the crania of past populations by antiquarians of the 19th century led to an unfortunate bias in the archaeological record. By either deliberately leaving the remaining skeleton *in situ* following excavation, a practice used routinely by Colt Hoare and Cunnington, or even worse, disregarding it afterwards, the absence of the axial skeleton in prehistoric collections has only inhibited a meaningful and considered approach to understanding the lives and health in antiquity.

However, during the 20th century some studies took a more thorough approach to skeletal analysis. Sir Arthur Keith, a medical Doctor, made a significant contribution to the study of human remains from archaeological contexts. He contributed clear and comprehensive bone reports to the excavation reports from Neolithic long barrows at Coldrum (1913) and Tinkinswood, Glamorgan (Ward, 1915), and analysed bones from early cave sites, such as Aveline's Hole (1924) and Kent's Cavern (1927).

A.J.E. Cave, Professor of Human and Comparative Anatomy at the Royal College of Surgeons, contributed his expertise to many Neolithic bone assemblages by writing comprehensive bone reports for excavations at Skendleby (1935), Notgrove (1936), and Adlestrop, (1938a). Cave provided a detailed inventory of the bones present, and charted new territory by discussing burial rites and taphonomic processes in Neolithic monuments. In his report on Lanhill long barrow, Wiltshire, Cave (1938b: 132) stated that the mortuary practice conducted within the tomb was one of successive burial, based on the fact that [the] "skeletons had been crowded to the back of the tomb to accommodate the entrance of the last burial." In addition, Cave's observations on post mortem damage to the human remains due to "grave pressure" and erosion, and his discussion on familial relationships within the group, due to the presence of Wormian ossicles on many of the skeletons, was a much needed improvement in the field of osteological studies (Cave, 1938b).

During the second half of the 20th century, two individuals, Calvin Wells, and Don Brothwell, brought the analysis of human remains from archaeological sites further forward to take a more bioarchaeological approach, more in line with what had been happening in the United States of America for decades (Roberts 2012: 8). By encouraging a more holistic approach, attempting to understand and contextualize human remains from archaeological sites, analysis by trained archaeologists and anthropologists, rather than enthusiastic medical doctors with an interest in archaeology, the field of Bioarchaeology became a true academic discipline in its own right (Smith and Brickley 2009: 38).

Wells was a prolific writer who had 150 publications to his name, including nearly 50 reports for archaeologists (including West Kennet Long Barrow, 1962a); important articles on paleopathological subjects such as leprosy (Wells, 1967) and Paget's Disease (Wells and Woodhouse, 1975); articles on non-inhumaned remains, such as mummification (Wells, 1962b) and cremations (Wells, 1960); and his seminal work, *Bones, Bodies and Disease* (Wells, 1964).

Brothwell was the prestigious author of many articles, chapters and books, not only in the field of archaeology and anthropology, but in the study of animal remains as well (Roberts 2006: 425). Of his 16 authored and edited books, two have remained very influential in the study of human remains from archaeological sites: *Diseases in*

Antiquity (Brothwell and Sandison, 1967), and *Digging up Bones* (1981). Brothwell wrote over 150 articles or chapters in books on a wide ranging number of subjects, such as Palaeodemography (1972), Palaeopathology (1961), the zoonoses (1991), and dental ageing (1989). In addition, he wrote bone reports for many excavated Neolithic sites, including Fussell's Lodge (1966), Millbarrow (1994), and Wayland's Smithy (Brothwell and Cullen, 1991).

Having firmly established the discipline of Bioarchaeology in the academic world, many scholars have published excellent books on Palaeopathology, including Juliet Rogers and Tony Waldron's *Field Guide to Joint Disease in Archaeology* (1995); Tony Waldron's *Palaeopathology* (2009); Charlotte Roberts and Keith Manchester's *The Archaeology of Disease* (2010); and Megan Brickley and Rachel Ives' work on *The Bioarchaeology of Metabolic Bone Disease* (2008). In addition, many specialised volumes have been published dealing with subjects such as children in the archaeological record (Lewis, 2007); human and animal teeth from archaeological sites (Hillson, 2005); Palaeodemography (Chamberlain, 2001, 2006); and cremation (McKinley, 1994, 2000).

Despite a lengthy history and thoroughly up to date techniques of analysis, the study of human remains from Neolithic sites has remained relatively scant. A recent study by Beckett and Robb (2006) has stated that of the known 137 British Neolithic sites that have yielded human remains, only 30 have been examined by a trained osteologist. Additionally, Smith and Brickley (2009: 148) state that there is a need to re-analyse older assemblages, which may reveal evidence of disease that was not recognised at the time. Furthermore, the health of the inhabitants of the Neolithic period has been based on only 24 sites from published reports (Roberts and Cox, 2003). Nevertheless, recent excavations at Haddenham (Evans & Hodder, 2006) and Hazleton North (Saville *et al*., 1990) have produced lengthy bone reports (Lee, 2006) and (Rogers, 1990), as has the re-analysis of the human remains from Ascott-under-Wychwood long barrow (Galer, 2006).

Haddenham long barrow in Cambridgeshire, was excavated between 1985 and 1987, and the report was finally published in 2006, outlining that a total of seven individuals were recovered from the monument, including five adults (two of which were considered to be male), one child and one infant (Evans and Hodder, 2006). Lee's 13 page report on the human remains discusses the age of the individuals (based on tooth eruption and attrition) and determination of sex (based on cranio-metric traits), without being specific about the methodologies used. Pathology, both dental and osteological; preservation and taphonomy; cut marks; and a section dedicated to interpretation of the site are also discussed (Lee, 2006).

Hazleton long barrow, Gloucestershire, was excavated between 1979 and 1982, with the excavation report following eight years later in two volumes in 1990 (Saville *et al*., 1990). A detailed 17 page report on the human skeletal material by Rogers, stated that a minimum of 41 individuals were interred within the monument, of which 22 were adults and 19 were children (Rogers 1990: 183). Estimation of age for the individuals was based on the patterns of eruption of the dentition and diaphyseal length of the long bones for those children under 12 years of age, with the degree of epiphyseal fusion of the skeleton being used for older juveniles (Rogers 1990: 183). The age of the adult skeletons was estimated by using the degree of attrition of the permanent dentition calibrated by Brothwell (1981), and by assessing the degree of change in the morphology of the pubic symphysis as documented by McKern and Stewart (1957) for males, and by Gilbert and McKern (1973) for the female individuals. Whilst not being able to indicate a specific biological age, the presence of many fragments of ossified cartilage within the assemblage, suggested the inclusion of older individuals within the tomb (Rogers 1990: 187). Determination of sex of the individuals was not attempted for the children, but the sex of the adult skeletons was assessed on the morphology of the *Os Coxae* as noted by Brothwell (1981) and cranium, and measurements of the size of the heads of the femur and humerus (Stewart, 1979). Because four different elements were selected to determine sex, the results differ in each case but show that there was preponderance of males to female in a ratio of 3:1 in the assemblage (Rogers 1990: 188).

In addition, the skeletal report includes sections on the estimation of stature of some of the individuals, using the regression formula devised by Trotter and Gleser (1952); the presence of any elements exhibiting non-metric traits, such as metopism, Wormian bones, squatting facets etc., as documented by Berry and Berry, 1967 (for cranial traits), and Finnegan (1978) for post cranial traits; dental and skeletal pathology, including caries and abscesses, joint disease, osteoporosis, and infection (Rogers, 1990).

Ascott-under-Wychwood long barrow was excavated by Benson between 1965 and 1969, with preliminary results and discussion following in papers by Chesterman in 1977, and Benson and Clegg in 1978. The human remains from the barrow have been re-analysed recently, following full publication of the site excavation report and new dating evidence (Benson and Whittle, 2007). The findings from the re-analysis of the human skeletal remains were outlined by Galer (2007) in a 33 page report, which states that the minimum number of individuals buried within the monument was 21, as opposed to the estimates given by Chesterman (1977) and Benson and Clegg (1978) of 49 and 46 individuals respectively. Of the 21 individuals, 17 were assessed as adults (including two cremation burials), comprising at least six males and three females, and the remaining four were children (Galer 2007: 192-209).

Estimation of age for the adult individuals buried within the tomb at Ascott-under-Wychwood was mainly based upon dental attrition (Brothwell, 1981), supported by morphological changes to the *Os Pubis* and auricular surface of the pelvis (the methodology used was not stated by Galer). The ages of the sub-adults were assessed by dental development, using the data devised by Buikstra and Ubelaker (1994) and by measurement of long bones (Maresh, 1955). In the case of neonatal remains, the data presented by Fazekas and Kósa (1978) were used.

Determination of sex was only attempted on the adult skeletons from the tomb, using morphological and metrical methods. The *Os Pubis* was assessed morphologically using the methods devised by Phenice (1969), and Acsádi and Nemeskéri (1970). In addition, cranial traits were assessed using the criteria outlined by Buikstra and Ubelaker (1994), and Acsádi and Nemeskéri (1970). The maximum diameter of the head of the humerus and femur were measured and compared to the data given by Stewart (1979).

The skeletal report also outlines the stature of some of the adult individuals where possible, using the data from Trotter (1970) and Tekla *et al*. (1962) for sub-adults. Furthermore, deposit analyses and case studies are discussed where individuals could be identified from the commingled remains, together with sections on preservation and taphonomy, health (infectious disease, congenital abnormalities, degenerative joint disease etc.), trauma, and dental anthropology.

In addition to these lengthy and detailed reports on excavated human skeletal material, several recent papers have added to the corpus of knowledge in Neolithic studies. Schulting and Wysocki (2005) revealed that the Neolithic period was not as peaceful as once perceived, with a significant proportion of crania analysed (between five and seven percent) from British sites showing signs of intense trauma. Indeed, one individual from Fussell's Lodge had three healed fractures to the cranium, indicating persistent interpersonal violence.

Several studies concerning isotopic analysis of Neolithic human remains have revealed dietary patterns in antiquity. Richards and Hedges (1999) and Schulting and Richards (2002) assert that marine sources were rapidly abandoned following the Neolithic revolution, in favour of terrestrial sources such as meat and crops. However, Milner *et al.* (2004) questions the validity of these claims, as they do not seem to be supported by the archaeological evidence. Whilst the authors admit that there is a definite shift in favour of terrestrial sources in the Neolithic diet, the results may have been biased due to the small sample size of the population tested, and to the fact that stable isotope analysis gives only a recent picture of the diet of a specific individual, not the eating habits of a whole community was over a long period of time (Milner *et al*. 2004: 18-19). Notwithstanding, Richards and Schulting (2006) strongly refute the comments made by Milner *et al.* (2004), and recommend that they engage with the isotopic evidence that clearly shows a rapid and clear change in dietary habits.

Recent research concerning the dating of human remains from Neolithic contexts using AMS has shown that long barrows were indeed a feature of the early Neolithic. Samples of human bone were taken from Lambourn long barrow in Berkshire, and were found to date to 3760 cal BC, a period right at the beginning of the Neolithic, suggesting that the transition from hunter-gathering to a more sedentary lifestyle was not as prolonged as initially thought (Schulting 2000: 32).

Within recent years, Whittle and Wysocki have carried out detailed analyses on some Welsh Neolithic tombs and the human remains buried therein. At Parc Le Breos, Glamorgan, taphonomic studies of the human remains were carried out in order to understand post mortem formation processes, revealing that both primary and secondary burial rites were practiced at the site; the latter being evidenced by the presence of weathered bone that had been scavenged by animals, a compelling scenario for the ritual of excarnation (Whittle and Wysocki 1998: 158). In the Brecknockshire Black Mountains, the inhumations from 14 monuments were studied for evidence of lifestyles, diversity and burial rites, in order to reconstruct the past lifeways of the communities represented and to measure degrees of conformity within them (Wysocki and Whittle, 2000).

Smith and Brickley (2009) published *People of the Long Barrows: Life, Death, and Burial in the Earlier Neolithic,* an up-to-date and concise synthesis of the human bone assemblages recovered from Cotswold-Severn monuments, which interprets available data from excavation reports, together with re-analysis on assemblages from Notgrove, Adlestrop, Sale's Lot, Burn Ground and Bowl's Barrow. Interpretation of Neolithic lifeways through skeletal analysis combines demographic appraisal with assessment of health and disease, burial practices and taphonomic factors.

The most recent research gets to the heart of studies concerning the Neolithic: were the people who facilitated the Neolithic revolution indigenous inhabitants of Britain, or migrants, introducing new ideas and belief systems to local populations? In addition, did this transition translate into sedentary mixed farming? Cassidy *et al*. (2016) have undertaken a programme of DNA analysis, sampling ancient whole genomes from Neolithic Irish individuals. The results indicate the arrival of early farmers to Ireland, with one inhumation from a megalithic tomb dating to 3343-3020 cal BC, possessing a genome with a marked Near Eastern signature. The results also showed that the individual descended from a large population, with some hunter-gatherer heritage.

Neil *et al*. (2016) have recently published their research into residential mobility of early farmers in Britain. Isotopic analysis was undertaken on teeth from the individuals interred within Hazleton North long barrow in Gloucestershire. The results show that instead of adopting cultivation in clearly delineated fixed plots, with domesticated animals in close proximity to permanent dwellings, the individuals from Hazleton North were far more mobile, and routinely moved to different geographical areas, and were not fully sedentary.

Recent research by Lipson *et al*. (2017) has revealed intriguing insights into population dynamics during the early Neolithic period in continental Europe. Analysis of ancient DNA samples revealed that early farmers who migrated to Europe from the Near East, spread quickly across the continent, where they co-existed with the local hunter-gatherer population for centuries, answering a long-held question of whether the migrants wiped out the native population on arrival (Lipson *et al.* 2017: 371).

Furthermore, the most up-to-date research reports that there are persistent genetic affinities between British and Western European populations from the Mesolithic period. Agriculture was rapidly introduced into Britain in the Neolithic period from Anatolian farmers who had followed a Mediterranean route of dispersal, and not the slower process of acculturation seen on the continent (Brace *et al.* 2018: 6).

In order to address the considerable knowledge gap in Neolithic burial assemblages, it was proposed that in *Enriching the Neolithic: The Forgotten People of the Barrows*, analysis of collections excavated in antiquity and later, would be undertaken using up-to-date techniques in an attempt to gain demographic profiles, assessments of health, disease and stature, leading to an assessment of belief systems from this important time in prehistory. Given that most Neolithic human remains are fragmentary in nature, or incomplete, the task was formidable but worthwhile, if a picture of life and death, 6000 years ago may be built up.

2.3: Summary

This chapter has outlined the contribution of scholars who have had an enduring fascination with the ancient monuments built in the Neolithic period. Documentary evidence reaches back centuries with the authors attempting to decipher the meaning of these enigmatic structures. Indeed, the prehistoric people of succeeding generations showed veneration for Neolithic monuments by interring their own dead within them or by constructing their own form of tombs nearby.

A remarkable tradition of recording the landscapes of prehistory, beginning in the 16th century, has resulted in a detailed and valuable record of, in some cases, vanished landscapes. Whilst some of the attention drawn to these enigmatic monuments has led to mistaken ideas of the considerable age of these constructions, the end result has led to the conservation and enduring fascination with these monuments. Much debate has surrounded the antiquity of Neolithic long barrows, and who was buried within them. Decades of sometimes reckless excavation in search of treasure was gradually replaced by a more considerate and careful approach in the appropriation of real data on the inhabitants of these structures. Careful analysis of the human remains excavated from long barrows began to be of importance. The lack of valuable artefacts within monuments perhaps focussed attention on why these tombs were built – the first structures ever to be constructed in Britain and what they signified. Progress has been made in the analysis of human skeletal material from this period. Not only are more detailed bone reports a normal inclusion in any good excavation report, they are vital in inferring the health, diet, demography, and structure of past populations.

Chapter 3 Funerary Practices and Longevity of Tomb Use

3.1 Introduction

The funerary practices of the Neolithic period in Britain reflect changing attitudes in belief systems and a human's place within their culture. For much of prehistory, humans were hunter-gatherers, who co-existed with nature and only exploited resources when needed. The introduction of agriculture facilitated a change in which the land was used and controlled, which inevitably brought about profound changes in human perceptions of life and death. This shift in worldview was expressed in the ways in which the dead were treated, not only by their contemporaries, but also by their successors. The creation of large monuments to house the dead, constructed of megaliths or earth, were a conspicuous addition to the landscape, and may have served to symbolise the control that a particular group had over the land (Fleming 1973: 189). Furthermore, the adoption of the land on which the tomb was constructed was an unequivocal gesture to neighbouring communities, validating their claim of ownership by the placement of ancestral remains within (Renfrew 1976: 206).

The form of the earliest monuments constructed in Britain is that of long mounds or long barrows. Monuments constructed of earth and wood (sometimes with small stones) are more common in the south and east, and are usually trapezoidal in shape and can be up to 100m in length (Field 2006: 21-23). Megalithic burial chambers, covered by stone are found predominately in the west and north of Britain, and include passage graves, portal tombs and gallery graves (Lynch 2004: 5). In recent years, the antiquity of oval and some round barrows has proved to be older than first thought. When Thurnam published the results of his exploration of sepulchral tumuli in 1869, he omitted these monuments, as he believed oval barrows to be, "doubtless late-British of the bronze and pre-Roman period, like the round barrows with which it must be classed" (Thurnam 1869: 174). The debate about Neolithic round barrows was brought to the fore by Kinnes (1979) who discussed the distribution and form of these less well known monuments, which vary in size from the enormous (the monuments situated within a bend in the River Boyne, County Meath, Ireland), to the relatively small, such as Handley 26 and 27 in Dorset.

3.2 Collective Burial

The dominant funerary rite in the Neolithic period is characterised by collective burial of the members of a community, either as a whole corpse, or as an assemblage of disarticulated bones (Pollard 1997: 50), although single burials within long barrows have been recorded, for example, at Whiteleaf Hill (Gordon Childe and Smith, 1955), Alfriston (Drewett, 1975), and Winterbourne Stoke 35a (Thurnam, 1869). The presence of primary burials (i.e. a fully articulated skeleton that is still arranged in the correct anatomical order) are fairly rare within the communal tombs of the Neolithic period but have sometimes been interpreted as the last burial within the tomb, as the corpse has been left to decompose *in situ* and had not been subsequently disturbed, such as the individual from Hazleton North long barrow (Saville *et al.,* 1990).

3.3 Secondary Burial

3.3.1 Re-arrangement

Secondary burial rites are the other most common form of funerary practice within Neolithic tombs, and are evident in three different forms which involve manipulation of the skeletal elements. The first example of secondary burial practice is evident when a corpse has been interred within a tomb and is allowed to decompose. The skeleton is subsequently disturbed and the different elements are re-arranged within the chamber, to make way for a fresh corpse (Beckett and Robb 2006: 60). Evidence for this rite was discovered at Midhowe, on Rousay, where an extended, fully articulated skeleton was placed on a stone bench above a skeleton that had been collected together in a pile on the floor, with the cranium placed on top (Reilly 2003: 137).

3.3.2 Removal of Selected Elements

Secondary burial rites are also evident in the archaeological record where skeletons have been manipulated within the tomb, and certain elements removed, to be placed elsewhere, such as in caves, causewayed enclosures, or curated by family members (Scarre 2007: 23). This funerary behaviour was discovered at Windmill Hill, where there is an over-representation of crania and long bones within the ditches (Whittle *et al*. 1999: 362) and at a cave complex in Yorkshire, where the site was used for the deposition of crania only, leading to the suggestion that the caves were used as an alternative to the causewayed enclosures of southern Britain (Leach 2008: 42).

Moreover, the long barrow at Chute was discovered to contain only a circle of crania surrounding bundles of long bones (Passmore 1942: 100).

3.3.3 Excarnation

The final manifestation of secondary burial in a Neolithic context is the practice of excarnation, which involves the exposure of a corpse out in the open to be picked clean by scavengers (Parker Pearson 2000: 29). This ritual seems anathema to modern western thinking, but the ceremony of Dokhmenashini is practiced today by the Parsees of India, who place the dead in “Towers of Silence”, where the copse is quickly stripped of flesh by vultures or other carrion birds, or left to desiccate in the sun (Vevaina 2013: 76). The purification of the body can only be attained by de-fleshing, as the corpse is seen as “dangerous and polluting” (Pollard 1997: 52), and once the bones were “dry”, they could be collected up and placed within the tomb (Parker Pearson 2000: 49).

Evidence for the ritual of excarnation has been discovered at causewayed enclosures but at few long barrows in Britain. An adult male inhumation was excavated from beneath a bank at the Windmill Hill causewayed enclosure, in Wiltshire, and was considered to have undergone the ritual of excarnation by Brothwell (1999: 344). The skeleton had been placed in a pit and left exposed for some time, which caused weathering to the surface of the bones. Further evidence was supplied by the presence of amphibian bones and raptor pellets in the grave.

Excarnation was considered by Smith (2006: 679) to be the cause of damage to all of the skeletons excavated from a long barrow at Adlestrop, in Gloucestershire. In each case, the proximal shaft of the femur had puncture wounds and furrowing consistent with gnawing by dogs. Furthermore, even in the absence of signs of scavenging to the bones, excarnation may be implied by the lack of small bones, such as those of the hands and feet, or hyoid and patella, which may have been missed by the community who collected the bones following exposure at the excarnation site, to be placed within the tomb elsewhere (Bello and Andrews 2006: 9).

3.4 Cremation

The last funerary rite practiced in the Neolithic period was cremation. This rite involved placing a corpse upon a pyre, which was then set alight, potentially reaching temperatures of 1000˚c, which could reduce a corpse to an oxidised state within three to seven hours (Piontek, 1976, cited in McKinley and Bond 2001: 284). When the ashes were cool, the cremated remains were collected by the community and either placed in pots or into the ground in pits (Parker Pearson 1999: 7). Cremation burials from the Neolithic period have been found in several contexts: the passage tombs of Ireland, Wales and Cornwall; causewayed enclosures, such as Etton in Cambridgeshire; stone circles; long barrows, such as Chestnuts in Kent, and Kill Barrow in Wiltshire; ring ditches, such as the monuments excavated in the 1950s by Atkinson, which were part of a Neolithic and Bronze Age complex at Dorchester-on-Thames, and which held a total of 104 cremation deposits in six circular monuments; and most famously Stonehenge, the largest cremation cemetery in Britain, which held the remains of at least 240 individuals (Alexander, 1961; Atkinson *et al.*, 1951; Parker Pearson *et al*., 2009; Thurnam, 1869).

The historical writers Pliny and Martial (cited in Toynbee 1971: 39) and anthropological reports, such as Robinson's depictions of the Australian Aborigines (in Hiatt, 1969), have all commented on the rite of cremation on funeral pyres. What all of these accounts have in common is the fact that pyre construction and purpose have been uniform for over 2000 years, and consist of a rectangle composed of layered timbers at right angles, filled in with brush wood or other such flammable material (McKinley 2000: 407).

Since the 1950s, many scholars have performed experiments with bones, whether animal or human, placing them on pyres to evaluate the amount of heat generated by the flames; differential bone colouration and morphology (Shipman *et al*., 1984), the sequence of collapse of the pyre; and whether dry and fresh bone (either defleshed or whole corpse) behave in the same way under the direction of combustion (Baby, 1954; Binford, 1963; Buikstra and Swegle, 1989; Heglar, 1984; Webb and Snow, 1974; Thurman and Wilmore, 1981; Ubelaker, 1978; and Wells, 1960). These important studies have aided in the interpretation of cremated bone assemblages from archaeological sites. Furthermore, these data suggest that when fresh bone is cremated on a pyre, the long bones exhibit longitudinal cracks, warping, thumbnail fractures and deep checking/crazing. Conversely, cremated dry bone exhibits only slight longitudinal fissuring, slight checking, but no thumbnail fractures and no warping.

However, further recent studies (Thompson, 2005; Gonçalves, *et al*., 2011) contest the idea that only fresh bone will warp when cremated, and the reasons for this.

Furthermore, experiments conducted on pyres have revealed that temperatures can exceed 1000º, although the pyre excavated at the Anglo-Saxon site at Spong Hill, Norfolk, must have reached temperatures of around 1200º, based on the melted bronze pyre goods (McKinley 1994a: 84). Cremation at these temperatures can reduce a corpse to an oxidized state within three to ten hours, depending on several factors, such as quality and quantity of wood; air flow within and around the pyre; and weather conditions (Pionteck, 1976, cited in McKinley and Bond 2001: 284). Unlike the modern cremation process, temperatures within the pyre cannot be maintained at a constant heat, therefore different areas of the corpse will burn at different temperatures, and for varying periods of time - the centre of the pyre is hotter than the periphery, resulting in differential degrees of oxidization of the bones (McKinley 2008: 167). The nature of cremated bone will be discussed fully in Chapter 4.

3.5 Longevity of Tomb Use in the Neolithic Period

For Piggott (1954: 380), the Neolithic period in Britain was separated into three phases; Early, Middle, and Late, starting in 2000BC and lasting only 500 years. Within a few years, the application of radio carbon dating on sites and assemblages introduced a new chronology, and indeed, a longer time span for the Neolithic period, extending from 4000Bc to 2000BC. The beginning of monumental building, including long barrows and causewayed enclosures, was placed within the Early Neolithic; round or oval barrows and cursus monuments in the Middle Neolithic; and henges in the Late Neolithic (Jones 2008: 184; Kinnes 1979: 72). The Early Neolithic period, when long barrows were considered to have been first built, was deemed to span from 4000BC to approximately 3500BC, when long barrows were sometimes constructed initially from mortuary enclosures and endured a long sequence of further development (Piggott 1966: 386; Kinnes 1992: 120). Indeed, the tombs were considered to have been in use as a depository for the community for up to a 1000 years by some (Darvill 1982: 26). Furthermore, despite the availability of radio carbon dates for some long barrows, most sites could only be placed within the wide timeframe of the fourth millennium cal. BC (Kinnes 1992: 120).

Within the last decade, the longevity of use for deposition of human remains within Neolithic long barrows has been challenged by a major archaeological dating project, which has necessitated a re-think of the chronology of the sites, but also, in the ideology associated with the monuments. In *Histories of the Dead: Building Chronologies for Five Southern British Long Barrows,* Bayliss and Whittle (2007) introduce seven papers detailing a new method of dating five well-known Neolithic long barrows, using a Bayesian statistical approach.

The method provides quantitative estimates of dates for events (the posterior beliefs) (such as when a long barrow was constructed, burials begin to be interred, and when they ceased) by inserting information that is already known (prior beliefs), such as stratigraphic sequences, into new data containing scientific dating evidence (the standardised likelihood), such as radio carbon dates. The resulting ‘posterior beliefs’ are interpretive estimates expressed as ‘posterior density estimates’ (Bayliss *et al*. 2007b: 4).

The application of the Bayesian method in the project permitted the five sites to be interpreted within a much narrower timespan – of human lifetimes or generations, rather than the hitherto allotment of vague parameters spanning the Early, Middle, or Late Neolithic period, or even worse, wide margins of time, such as the radio carbon date for Wayland’s Smithy I, which was placed between 3890 – 3120 cal. BC. (Whittle *et al.* 2007b: 108).

The surprising results from the study indicated that the five sites were used for the deposition of human remains for less time than had been previously thought. Ascott-under-Wychwood long barrow and the Fussell’s Lodge mortuary structure were in use for the longest time, but for only up to a century, or three to five generations (Bayliss *et al*. 2007a: 42; Wysocki *et al*. 2007: 82). Hazleton long cairn was only used for two to three generations (Meadows *et al*. 2007: 54) and West Kennet long barrow for approximately one generation (Bayliss *et al*. 2007c: 94). The use of Wayland’s Smithy long barrow for the interment of the dead was even shorter, spanning less than one generation, suggesting that the 14 individuals buried beneath the oval structure (Wayland’s Smithy I) may have suffered a single event, such as devastating illness (Whittle *et al*. 2007b: 118).

What was also reasonably clear from the study was that none of the long barrows had been constructed before 3750 cal. BC and that each site had a different date for the start of construction. Ascott-under-Wychwood was the oldest long barrow, the first human remains were interred 3750 – 3690 cal. BC (95% probability) (Bayliss *et al.* 2007a: 40), followed by Fussell's Lodge long barrow, which was built between 3700 – 3630 cal. BC (Wysocki *et al*. 2007: 81). Hazleton North long cairn was built between 20 to 95 years after the initial construction of Ascott-under Wychwood long barrow (95% probability) (Meadows et *al.* 2007: 62), and the West Kennet long barrow was constructed between one and 55 years later (94% probability) or 15 to 45 years later (68% probability) (Bayliss *et al*. 2007c: 96-97). Finally, Wayland's Smithy was the last monument in the series to be built (100% probability) (Whittle *et al*. 2007b: 117).

This influential project has re-opened the debate about the potential ideological purpose of Neolithic long barrows. If the monuments were used for burials for only a relatively short time span, and not for hundreds of years, the concept of ancestor worship seems less likely. Indeed, Whittle *et al*. (2007a: 132) state that the community would have real memories of the dead buried within the tomb and not of faceless and distant ancestors, spanning the centuries. Furthermore, the study revealed that, apart from Fussell's Lodge, there was no evidence of any ancestral human remains at the sites. Despite the human remains being disarticulated and incomplete within the other four sites, there was little evidence to suggest that the bones were not contemporaneous (Whittle *et al*. 2007a: 133). However, the authors did not completely dismiss the importance of ancestors in this period and suggest that following a fairly short span of use, the monuments were sealed, but not forgotten, and having lived out a rapid and intense period of activity, were relegated to the realm of the 'ancestors'.

In addition, this project asserted that the dominant burial rite at the five sites was of successive deposition of whole corpses. The mass of disarticulated remains within the tombs were probably created when moving aside one decomposing or decomposed corpse to make way for another fresh body. All of the tombs in the study, except Fussell's Lodge, contained articulated or partially articulated skeletons, and a pattern emerges of increasing intensive treatment of the human remains where greater numbers within the tomb occurred (Whittle *et al*. 2007a: 130). Hazleton North long barrow contained between 40 and 50 individuals which had been deposited over a period of two to three generations and 21 individuals had been interred within the long barrow at Ascott-under-Wychwood over the period of three to five generations. Even though the tomb at Ascott-under-Wychwood was in use longer, the human remains within Hazleton long barrow were far more disturbed and scattered (Whittle *et al*. 2007a: 130).

The use of a Bayesian statistical framework to interpret the chronology of Neolithic long barrows has allowed new insights into the longevity of tomb use and the ideology of the communities that constructed and used them. Indeed, the project has forced a new appraisal of burial practices and altered the accepted perception which focused on ancestor worship, to perhaps, realising that what appears in the archaeological record may be more a product of a practical nature, and not purely ritual.

3.6: Summary

This chapter has outlined the burial practices in the Neolithic period, with collective burial, either as whole corpses, or assemblages of disarticulated bones, the dominant rite. Single burials are known at some sites, raising the question of why such enormous physical entities were built with such an intensive amount of labour just for one individual. Primary burial was practiced at some sites, but this does not appear to have been the normative behaviour, and in fact is only usually exhibited as the last burial to be interred within the tomb, where it would lay untouched until excavation.

Secondary burial was also practiced in the Neolithic period in the form of the re-arrangement of the bones within the tomb; the selective removal of some bones to be placed at other sites, such as caves or causewayed enclosures; or by the practice of excarnation, which was thought to be rare at long barrow sites.

Cremation was also performed at some sites, either as the only rite, or in conjunction with inhumation burials. Analysis of the cremated human remains is an important area of research, as the physical properties of the charred bones allows interpretations of pyre technology to be made. The wide range of colouration and fracture patterns on the bones give insights into the temperatures achieved in the pyre, grave goods and ritual.

Longevity of tomb use was also discussed, with new research challenging long held ideas that long barrows were built over a long period and were in use as houses of the dead for centuries. Using Bayesian statistical analysis, Bayliss and Whittle and colleagues have produced new estimates for when the different tombs were constructed, burials began to be interred, and when burials ceased. The surprising results revealed that the monuments were built quickly and only used for generations, with the longest time span of use at Fussell's Lodge and Ascott-Under-Wychwood. West Kennet long barrow was only in use as a burial context for only one generation, and Wayland's Smithy for even less. This important project has highlighted the need for new debate about the ideological purpose of long barrows, as the long thought of concept of ancestor worship may have been far from what was intended by the communities who built them.

Chapter 4: Materials and Methods

4.1 Materials Examined

Initial research for the current study identified 120 Neolithic sites from southern Britain which were reported to contain human skeletal remains. Of these, 50 were available for research (unfortunately seven remain unanalysed due to time constraints), the remaining 70 were not, for the various reasons discussed below (listed by site in Appendix 1).

Colt Hoare and Cunnington excavated many Neolithic monuments in the early nineteenth century and often reburied the human remains that were recovered (Thurnam 1869: 198). However, between 1855 and 1867, Thurnam re-excavated many of the sites, removing the re-interred skeletons for the purpose of study. He did not, however, either re-excavate or locate the burials from nine monuments: King Barrow, Boreham; Wilsford 30; Stockton; Knook 5; Corton; Heytesbury 4; Winterbourne Stoke 53; Arn Hill; and Silver (Orcheston 4). Secondly, nine of the sites that were recorded as having contained human remains, have consequently revealed that any supporting reports were either unofficial or unrecorded, and that the burials were either not retrieved, or were subsequently lost. Furthermore, the human remains from six sites were unavailable to study, due to the fact that they have been officially declared "lost", in most cases due to bomb damage inflicted during World War II, such as the burials from Priddy long barrow which were stored in a facility in Bristol.

In 2015, the Anthropology Collections Department at the Natural History Museum announced its intention to close the collection to researchers, due to the relocation and re-sorting of the vast archive. As a result, it was not possible to get access to the bones derived from ten long barrows which were relevant to this study, such as those from Wayland's Smithy (Oxfordshire); Fussell's Lodge; Lanhill; Norton Bavant (Wiltshire); Rodmarton; West Tump; Cow Common Long; Pole's Wood South; Pole's Wood East (Gloucestershire); or Coldrum (Kent). However, in four cases (Lanhill; Rodmarton; Norton Bavant; and West Tump) the Natural History Museum only retained a small percentage of the material recovered from excavation, the majority of the bones from these sites being held by other institutions.

Within the last decade, five of the sites deemed relevant to this project (Notgrove, Adlestrop Hill, Sale's Lot, and Burn Ground, all located in Gloucestershire, and Ascott-under-Wychwood, Oxfordshire) have been thoroughly re-assessed by experienced osteologists (Smith and Brickley 2009 and Galer 2006, respectively), and it was therefore decided not to analyse these assemblages again, as modern techniques would have been employed, and little new information would be gleaned.

The human skeletal remains excavated from Winterbourne Stoke 1 long barrow (Wiltshire) are currently on display in the Stonehenge Visitor Centre as part of a new exhibition, and were therefore not available for analysis. Lastly, despite considerable effort, it has not been possible to locate the remaining 34 assemblages.

Despite these obstacles, the human skeletal remains from the 43 Neolithic long barrows analysed for the current study produced a wealth of data, although the assemblages varied considerably in completeness (N.B. The human remains excavated from Sperris Quoit, Cornwall, can at best be described as scant. The recovered cremated bone was presented in a matchbox, and was represented by a few flecks of material. In fact, without microscopic analysis, it would be impossible to discern whether the bone is even human. Therefore, the material from Sperris Quoit will not be included in any of the data in the current study, and the number of sites discussed will henceforth be 42). Table 4.1 below shows the sites analysed, the number of inhumations reported to have been found following excavation, and the actual number of individuals available for study. In four cases, the minimum number of individuals estimated after analysis was greater than those reported. Broadsands long barrow, Devon, was excavated in 1958 by Ralegh Radford, and was reported to contain the human remains of four individuals: one mature adult male; two young male adults; and one infant (Ralegh Radford, 1958). Fresh analysis of the assemblage revealed the bones of at least three adult males (based on the measurements of three left tali), one juvenile, one infant, and at least one adult present in a cremation burial.

Fromefield long barrow, Somerset, was excavated in 1965, and estimated to hold the remains of 15 individuals, based on the presence of 13 pairs of metatarsals, and the bones of two infants (Vatcher and Vatcher, 1973). Following re-analysis, the minimum number of individuals represented was increased to 18, supported by the presence of: ten adult metatarsals (right 4th metatarsal); one neonate; four children aged two (left clavicle), four (mandible), aged between nine and ten years old (right clavicle), and the last aged between ten and eleven years (right clavicle). In addition, one juvenile of between 14 and 16 years of age (based on epiphyseal fusion, plus a right fourth metatarsal), and two between eleven and sixteen years were present (two further right fourth metatarsals).

Avenis long barrow, Gloucestershire, was excavated by WH Paine in 1865, who reportedly found the remains of two adults and one infant. Re-analysis found the existence of three adults, based on the presence of three right maxillae, and two young children (one individual of one to two years, and one of between three to five years) based on fused and unfused thoracic vertebrae.

The six burials from Wor Barrow, Dorset (Pitt Rivers, 1898), were the primary interments from beneath the mound, within a rectangular wooden structure. However, two more individuals were recovered from within the surrounding ditch, in stratified Neolithic deposits. One was available and included and re-analysed for this study.

Table 4.1: Sites re-analysed and minimum number of individuals reported vs actual minimum number of individuals available for study.

SITE	# REPORTED BURIALS	ACTUAL # ANALYSED	DIFFERENCE IN NUMBER
Avening	**11**	**3**	**-8**
Avenis (Smart's Farm)	**3**	**5**	**+2**
Belas Knap	**36+**	**19**	**-c17**
Bown Hill (Woodchester)	**6**	**3**	**-3**
Bratton Camp	**1/2**	**1**	**-1**
Broadsands	**4**	**6**	**+2**
Chestnuts	**9**	**7**	**-2**
Figheldean Down (31)	**1**	**1**	**0**
Fittleton Down (5)	**?**	**1**	**+1**
Fromefield	**15**	**18**	**+3**
Fyfield (Giants Grave)	**3/4**	**2**	**1/2**
Gatcombe Lodge	**2**	**1**	**-1**
Giant's Hills (Skendleby I)	**9+**	**6**	**-c 3**
Haddenham	**7**	**5**	**-2**
Handley 26	**2**	**1**	**-1**
Handley 27	**?**	**1**	**+1**
Hazleton North	**41**	**41**	**0**

Hetty Pegler's Tump (Uley)	**24+**	**5**	**-c 19**
Horton Down (Bishops Cannings 91)	**?**	**1**	**+1**
Imber (Bowls Barrow)	**14**	**5**	**-9**
Jackbarrow	**?**	**3**	**+3**
Kings Playdown (Heddington 3)	**1**	**1**	**0**
Lamborough Banks (Ablington)	**1**	**1**	**0**
Lanhill	**22+**	**8**	**-c14**
Littleton Drew (Lugbury)	**26**	**12**	**-14**
Luckington (Giants Cave)	**25**	**11**	**-14**
Millbarrow	**13**	**8**	**-5**
Netheravon Down (6)	**2**	**2**	**0**
Norton Bavant	**18**	**12**	**-6**
Nympsfield	**16+**	**9**	**-c 7**
Oldbury Hill	**3**	**3**	**0**
Randwick	**7**	**3**	**-4**
Rodmarton	**13+**	**12**	**-c1**
Stonehenge (Amesbury 14)	**3**	**3**	**0**
Stoney Littleton	**16**	**2**	**-14**
Tilshead East (7)	**8**	**8**	**0**
Tilshead Lodge	**2**	**2**	**0**
Tilshead Old Ditch	**3+**	**1**	**-c 2**
West Tump (Cranham)	**20**	**1**	**-19**
Winterbourne Monkton	**31**	**22**	**-9**
Wor Barrow	**6**	**7**	**+1**
West Kennet	**54**	**42**	**-12**
TOTAL	**480**	**305**	**-175**

The reported number of burials excavated (n=480) compared to what was actually available for study (n=305) was lower in 25 cases, and amounts to a loss of 175 individuals, which equates to 36% of the original assemblages. This deficit may be partly due to the fact that several assemblages have been separated and stored in different locations, with the result that boxes may have been lost or mislabelled on re-location. For example, the human remains recovered from Norton Bavant long barrow, Wiltshire, and West Tump long barrow, Gloucestershire, are stored in two different locations, one of which is the Natural History Museum in London, which was at the time of writing, closed to researchers. Furthermore, the human remains excavated from the sites at Lanhill long barrow, Wiltshire, and Nympsfield long barrow, Gloucestershire, are each stored in three different institutions, further complicating access. Despite storage issues, the numbers still do not add up and it may be the case that the original number of individuals represented on excavation were miscalculated or perhaps exaggerated.

The number of burials from nine sites corresponded to the number of individuals available for study. However, in none of these cases was an individual represented by a whole skeleton – the majority are only represented by a cranium and mandible. Five of the eight sites mentioned were excavated by Thurnam in the mid nineteenth century, whose overriding focus was on crania, to the detriment of the remaining skeleton. It would therefore appear that only these parts of the skeleton were retained by him, and the others lost or disposed of.

4.2 Methodology

The methodology for analysing inhumation and cremation burials will be discussed separately due to the fact that the criteria used for analysing inhumation burials and cremation burials may not be the same. This is mainly due to the fact that cremation burials may not contain the diagnostic elements necessary for analysis: when the cooled remains were collected from the funeral pyre, usually only approximately 50% of the bones were collected (either due to selection, or the remains having been reduced to irretrievable dust). Of these remains, approximately 30% to 50% of the assemblage will be identifiable (McKinley 2000: 408).

4.2.1 Inhumation Burials

4.2.1.1 Completeness

The bone assemblages from the Neolithic sites were expected to be disarticulated, fragmentary and commingled, due to cultural manipulation and the insertion of later burials. Initially, the bones from each tomb were sorted according to element where possible, whilst maintaining the integrity of any discrete groupings (i.e. bones arranged in separate piles within the tomb, or placed in different chambers etc.). The fragmented nature of the assemblage necessitates a different approach for recording purposes, as most standard recording methods have been devised with complete skeletons in mind. Therefore, the Zonation Method devised by Knüsel and Outram (2004) was used for the skeletal inventory to pinpoint the region of the bone represented, giving a far more accurate picture of the part of the bone present for analysis (for example, the mandible is divided into seven zones). Fragments of bone too small to identify to element were recorded by using Outram's (2001) method, which divides bone into size order and then counted.

4.2.1.2 Recording

Each bone fragment was recorded on a spreadsheet, using Excel, and giving details of the element represented, size/fragmentation, side (where possible), zone, degree of fusion, age, sex, trauma/pathology, non-metric traits, and preservation and taphonomic details. The condition of bone can be informative when interpreting formation processes and help to build up a picture of ritual activity. Therefore, each element was examined for signs of weathering, and scored using the recording system devised by Behrensmeyer (1978), with the caveat that this method was devised using animal bones, which weather differently from human bone (Brickley and McKinley 2004: 6). In addition, preservation scores were given using the system set out by Brickley and McKinley (2004) to record areas of abrasion and erosion. Evidence of fracturing to the bones was also noted, as the morphology of the break can infer whether the event was of the result of human agency or of formation processes (Lovell 1997; Lyman 2001; Outram 2001; Villa and Mahieu 1991).

Each fragment of bone was measured using sliding or spreading callipers and an osteometric board. Whole long bones can give an estimate of stature (Trotter, 1970), and therefore, an indication of health through access to diet and living conditions.

4.2.1.3 Calculation to Determine the Number of Individuals Present

An estimate of how many people are represented in the assemblage from each site was calculated by the MNI, using the most abundant zone or element present, after sorting by side and by age. This method is particularly useful when dealing with fragmentary remains but has limitations, as the number of individuals derived represent the recovered assemblage, not the original number of individuals represented.

4.2.1.4 Estimation of Age at death

Adults

Estimation of age at death of a skeleton was based on morphological and metrical data. However, these data will provide a biological age at death, which is not necessarily the same as chronological age (Gowland 2006: 143). A skeleton may exhibit increased age due to disease or stresses placed on the body. Nevertheless, an indication of biological age is still very useful when studying archaeological human remains.

However, there remain some factors which affect the estimation of age at death for archaeological human remains. Foremost is the fact that the age estimations formulated by osteologists have been ascertained from collections of human remains from around the world that date mostly to the nineteenth and twentieth centuries, the oldest assemblage coming from Christ Church, Spitalfields in London, which is from the eighteenth century (White *et al*. 2012: 383). Therefore, using relatively modern skeletons to age prehistoric human remains may be problematic, as the lifestyles of the two groups will be markedly different and can have a dramatic effect on the human skeleton (White *et al*. 2012: 384).

In addition, estimating the age at death of adults may be problematic because, following maturation of the skeleton between the ages of 25 to 30 years, the bones will begin to deteriorate in a non-linear fashion, which may be affected by lifestyle and health. Furthermore, the methods used to discern this degeneration are based on morphological changes which may suffer from observation error (Byers 2010: 202). Despite these limiting factors, it is possible to estimate age at death for archaeological human remains by using broad age categories (Table 4.2). Therefore, the methods for estimating age at death for adults in the current study were based on several methods.

Table 4.2: Age classes used in this study (Ubelaker and Buikstra, 1994).

Age Class	Age in Years
Pre-term baby	Before Birth
Infant	0 – 3 Years
Child	3 – 12 Years
Adolescent	12 – 20 Years
Young Adult	20 – 35 Years
Middle Adult	35 – 50 Years
Old Adult	50 + Years

Ectocranial suture closure (Meindl and Lovejoy, 1985) is based on the fact that the sutures of the cranium fuse with advancing age. The degree of suture closure will be recorded for ten ectocranial locations according to five stages (Table 4.3).

Table 4.3: Stages of cranial suture closure (Meindl and Lovejoy, 1985).

Stage	Characteristic
Blank	Unobservable
0	Open
1	Minimal Closure
2	Significant Closure
3	Complete Obliteration

The Vault sites are: 1. Midlambdoid, 2. Lambda, 3. Obelion, 4. Anterior sagittal, 5. Bregma, and the Lateral-Anterior sites are: 6. Midcoronal, 7. Pterion, 8. Sphenofrontal, 9. Inferior sphenotermporal, and 10. Superior sphenotemporal (Figure 4.1). Both systems use the pterion and midcoronal sites, therefore, the vault system has a score of between 0 – 21, and the lateral-anterior system has a score of between 0 – 15.

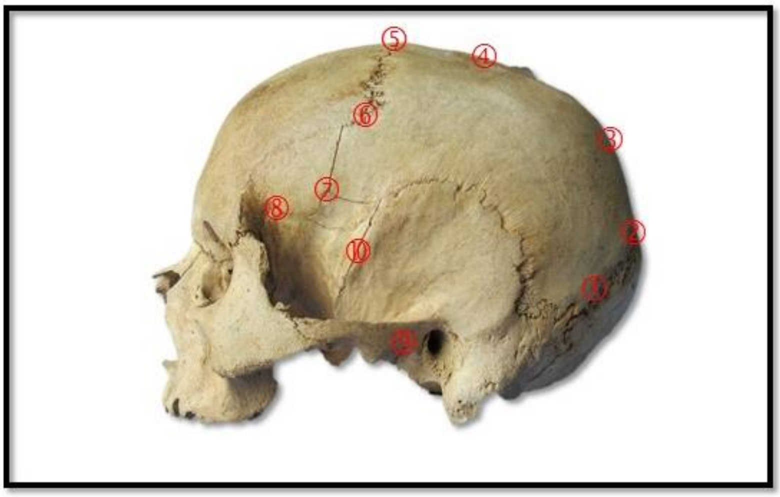


Figure 4.1: Location of sites for ectocranial suture closure system (after Meindl and Lovejoy, 1985).

The scores for each system can then be added together to get a composite score and an "S" designation (Table 4.4), which can then be used to get an age estimation. Meindl and Lovejoy note that the Lateral-Anterior system is a better predictor of chronological age than the vault system (Meindl and Lovejoy 1985: 62).

Table 4.4: Composite scores for the vault and lateral-anterior systems (Buikstra and Ubelaker 1994, 36, after Meindl and Lovejoy 1985).

Composite Score	Vault System	Lateral-Anterior System
S1	1 - 2	1
S2	3 - 6	2
S3	7 - 11	3 - 5
S4	12 - 15	6
S5	16 - 18	7 - 8
S6	19 – 20	9 - 10
S7		11 - 14

The ectocranial suture closure system (Meindl and Lovejoy, 1985) should not however, be used in isolation to estimate age at death for archaeological specimens, as its reliability has been questioned by some scholars. Masset (1989) states that the considerable variation rates of suture closure reduces the effectiveness of the method to estimate age at death. In addition, Key *et al*. (1994) used the method on a collection of human remains of known age from Spitalfields in London, and found that the results were skewed by sexual dimorphism in the rate and pattern of suture closure. This finding was echoed by Hershkovitz *et al*. (1997), who also considered cranial suture closure patterns to be genetically inherited.

Estimating age at death from tooth wear is a useful tool because once a permanent tooth has erupted, it begins to wear. Therefore, an attrition chart devised by Brothwell (1981), who derived the pattern of tooth wear from a sample of British skeletons ranging from the Neolithic period to the medieval period combined with wear of the pubic symphysis, was used.

Epiphyseal fusion of the skeleton is a useful method when estimating age at death for adults, in particular, when distinguishing between younger adults and older adults. In general, it is the mid-line elements that fuse last, such as the medial clavicle, and the iliac crest of the os coxae (Cunningham *et al.* 2016: 13). However, unless the adolescent growth spurt has passed, and secondary sexual characteristics are reflected in the skeleton, it may be difficult to estimate age, because fusion times vary between the sexes, and indeed, individuals (Cunningham *et al*. 2016: 11).

A reliable method of estimating age at death is the Suchey-Brooks pubic symphysis scoring system (1990), which is based upon the changing topography of the surface of the bone. As an individual ages, the surface of the pubic symphysis changes from a billowed appearance, with ridges and furrows (Phase 1), to an eroded surface, surrounded by a rim (Phase 5/6) (Table 4.5).

This system was devised using a sample of 1225 individuals of known age from autopsies carried out by the Chief Medical Examiner of Los Angeles (Brooks and Suchey 1990: 228), and has been tested by various scholars for its accuracy. Klepinger *et al.* (1992) compared three methods for estimating age at death by using the *Os Pubis,* and stated that the Suchey-Brooks method was the most superior, with the caveat that the racial refinement was to be used. In addition, it was recommended that any age estimate should be stated within a standard deviation interval of plus or minus two years. More recent studies by Martrille *et al*. (2007) and Fleischman (2013) both concluded that the method devised and Brooks and Suchey (1990) was indeed reliable, but was most accurate for young adults within the 25-40 years old range.

Table 4.5: Age ranges using the Suchey-Brooks (1990: 233) pubic symphysis scoring system.

	Female			Male		
Phase	Mean	Standard Deviation	95% Range	Mean	Standard Deviation	95% Range
1	19.4	2.6	15 - 24	18.5	2.1	15 - 23
2	25.0	4.9	19 - 40	23.4	3.6	19 - 34
3	30.7	8.1	21 - 53	28.7	6.5	21 - 46
4	38.2	10.9	26 - 70	35.2	9.4	23 - 57
5	48.1	14.6	25 - 83	45.6	10.4	27 - 66
6	60.0	12.4	42 - 87	61.2	12.2	34 - 86

Another method of determining age at death using the pelvis, is a system devised by Lovejoy *et al*. (1985) which uses age-related changes to the auricular surface of the ilium. As an individual ages, the auricular surface ranges from a billowed and very fine granularity (Phase 1), to a breakdown of the surface, with marginal lipping, macroporosity, increased irregularity, and marked activity in preauricular areas (Table 4.6). This method has two advantages over using the pubic symphysis for determination of age at death: the auricular surface is more likely to be preserved in archaeological contexts; and the ages ranges are more closely defined using this system. However, this method has been criticized by Saunders *et al*. (1992), who assert that the estimated ages for the older individuals in the sample were underestimated, and that the age ranges were not fluent enough to allow for individual variation. In addition, the percentage of intraobserver error was high at 19.3% (Saunders *et al*. 1992).

In an attempt to rectify these problems, Buckberry and Chamberlain (2002) revised the methodology of Lovejoy *et al.* (1985) by evaluating each age-related change (i.e. macroporosity, transverse organisation and so on) separately, and then scoring it accordingly. In 2005, Mulhern and Jones applied both of these methods to a sample of 309 individuals from the Smithsonian Institute, Washington DC. Their findings suggest that the method devised by Lovejoy *et al.* (1985) was reliable for estimating the age at death for individuals aged between 20 and 49. Conversely, Buckberry and Chamberlain's method was accurate on older individuals aged between 50 and 69.

Table 4.6: Age ranges by phase for estimating age at death using the auricular surface (Lovejoy *et al*. 1985, 17).

Phase	Age Range
1	20 - 24
2	25 - 29
3	30 - 34
4	35 - 39
5	40 - 44
6	45 - 49
7	50 - 59
8	60 +

Subadults

Determining the age at death for subadults was be based on age-related changes that occur in a predictable sequence. Therefore, several methods may be used: diaphyseal length (Fazekas and Kósa, 1978; Hoffman, 1979; Schaefer *et al*., 2009); appearance of centres of ossification and fusion (Schaefer *et al*., 2009); and dental development and eruption (Moorees *et al*., 1963a, 1963b; Smith, 1991). However, in the case of prehistoric human remains, emphasis must be placed on the methods for determining age at death using dental development, as subadults may have suffered stunted growth, skewing the results (Cunningham *et al.* 2016: 13). Dental development is generally not arrested by environmental stresses, and is therefore more reliable (Smith 1991: 143).

4.2.1.5. Determination of Sex

Determination of sex of human skeletal remains is based upon growth changes during adolescence which are caused by sex hormones circulating in the body. The most obvious and reliable elements demonstrating these differences are the bones of the pelvic girdle, which are much wider in a female to allow child bearing, and the cranium, because the muscle attachments are more robust in males (Buikstra and Ubelaker

1994: 19). In fact, most of the bones of the human skeleton are sexually dimorphic, with the male elements being up to 20% larger (White *et al*. 2012: 411).

Adults

Therefore, the methods for determining sex for adults in the current study were based on morphological and metrical techniques. Firstly, using the pelvic bones, measuring the os coxae using DSP (Murail *et al*., 2005), a tool for probabilistic sex diagnosis which the authors state is close to 100% accurate (even on fragmented bones, depending on obtaining at least four measurements). In addition, visual determination of the os coxae (Bruzek, 2002; Phenice, 1969) was also used, and which is reported to have accuracy levels of 95%, and between 59% and 96% accuracy respectively.

Secondly, using the cranium, a scoring system for sexually dimorphic cranial features (Buikstra and Ubelaker, 1994); mandibular ramus flexure, which reports an accuracy level of 94.2% (Loth and Henneberg, 1996); and sexual dimorphism of the *pars petrosal ossis temporalis* (66.6% accurate, Wahl and Graw, 2001).

Lastly, measurement of individual elements, such as the scapula, humerus and femur (Mall *et al*., 2001; Stewart, 1979), clavicle (73.3% - 88.3% accuracy, Akhlaghi *et al*., 2012), talus and calcaneus (87.9 - 95.7% accurate, Gualdi-Russo, 2007), and radius (92% - 94% accuracy, Berrizbeitia, 1989) (Table 4.7).

Table 4.7: Measurements used for determination of sex (in mm).

Element	Measurement (mm)	Male +/-	Ind	Female +/-	Population Used	Reference
Clavicle	Max length Max length Max mid-shaft circ.	>150 147.208 10.374 44.07 5.358	>138	<138 130.37 8.609 38.38 5.260	English Iranian Iranian	Parsons, 1916 Akhlaghi *et al.*, 2012 Akhlaghi *et al.*, 2012
Scapula	Max length Glenoid length	>170 >37	 36-34	<140 <36	Black & White USA	Stewart, 1979 Stewart, 1979
Humerus	Vertical head diameter Epicondylar width	>47 >61.5	47 - 43	<43 <60.8	Black & white USA Modern Germany	Stewart, 1979 Mall *et al.*, 2001
Radius	Head diameter	>24		<21	Black & white USA	Berrizbeitia, 1989.
Femur	Head diameter	>47 – 46.5	46.5 - 43.5	<43.5 – 42.5	Black & White USA	Stewart, 1979.
Talus	Max length Width Height	R 56.1 2.9 L 56.1 2.9 R 43.3 2.2 L 43.4 2.2 R 32.3 1.8 L 32.6 1.7		R 49.2 2.3 L 49.3 2.1 R 38.3 2.2 L 38.5 2.0 R 29.0 1.4 L 29.2 1.2	Modern Italy	Gualdi-Russo, 2007
Calcaneus	Max length Breadth Height	R 81.5 4.4 L 81.6 4.4 R 43.7 2.4 L 43.7 2.3 R 43.1 2.8 L 43.0 2.9		R 73.1 3.4 L 73.5 3.2 R 38.3 2.0 L 38.2 2.0 R 38.2 2.4 L 38.3 2.6	Modern Italy	Gualdi-Russo, 2007

Subadults

Considering that sexual dimorphism of the human skeleton is most noticeable following the onset of puberty, it is problematic to accurately determine the sex of subadults, and is generally not recommended (Cunningham *et al*. 2016: 18). However, some morphological methods have proved useful: sexual dimorphism of the skull (Molleson *et al*., 1998), which records an accuracy level of 78%; and the ilium and mandible (Schutkowski, 1993), recording an accuracy level of between 70 % – 90%. However, Vlak *et al*. (2008) found the method devised by Schutkowski (1993) unreliable in a study of Portuguese children. They reported that the sciatic notch morphology tends to have a more female appearance below the age of one year but appears to resemble that of a male between the ages of six and fifteen years (Vlak *et al.* 2008: 313-314).

4.2.1.6 Non-Metric Traits

Non-metric traits of the human skeleton refer to non-pathological differences in the morphology of the bones and, and can be expressed in the shape of tubercles, processes, crests, foramina, articular facets, and other features. In addition, teeth can also show these variants in the shape and size of cusps and roots (White *et al*., 2012). The importance of studying these features is that the presence of similar non-metric traits within a group may be indicative of familial inheritance. Buikstra and Ubelaker (1994) have compiled a list of 24 of the most import traits (21 cranial and 3 post cranial) recorded by Berry and Berry (1967) and Finnegan (1978), with the proviso that all traits must be recorded as present or absent.

4.2.1.7 Trauma and Pathology

Each tooth, element or fragment of bone was macroscopically examined for signs of trauma or pathology, using photographs where necessary. Following the guidelines suggested by Roberts and Connell (2004: 35), the following details were recorded on the spreadsheet: which bone/tooth is affected (including side); the part of bone/tooth (e.g. proximal shaft) and aspect (e.g. medial) affected; the nature of the lesion (forming, destroying, mixed); the nature of any new bone formation (woven, lamellar, or in process of healing); if there is evidence of bone destruction, is there any sign of healing (e.g. rounding of the edges of the lesion); the distribution pattern and measurements of lesions; and finally, to offer a differential diagnosis where possible. In addition, periodontal disease, attrition and calculus on the dentition was recorded as present or absent (and the severity of the conditions noted as per Brothwell, 1981). Other signs of dental disease (caries, abscesses and enamel hypoplasia) were recorded on the spreadsheet, noting the location of the defect, together with an assessment of tooth wear, which were recorded according to Smith (1984).

Where there was evidence of porotic hyperostosis or cribra orbitalia, the recording system devised by Stuart-Macadam (1985) and adapted by Buikstra and Ubelaker (1994) was used to indicate degrees of severity.

In addition, descriptions of congenital and developmental abnormalities, infection, joint disease, metabolic disease, and neoplastic disease were recorded and photographed accordingly. The pathology texts consulted included: Aufderheide and Rodríguez-Martin, 2008; Brickley and Ives, 2008; Hillson, 2005; Ortner, 2003; Mann and Hunt, 2005; Resnick, 2002; Roberts and Manchester, 2010; Rogers and Waldron, 1995; and Waldron, 2009. In addition, relevant clinical journals were consulted.

In the case of fragmented or broken bones, the type of fracture was examined to determine whether the break is a dry fracture, sustained long after death, or a peri-mortem fresh fracture.

4.2.2 Cremation Burials

As with the bones from inhumations, if the assemblage was presented in separate bags, the integrity of the individual groups was kept, collating the data afterwards. Initially, the whole assemblage was weighed, then separated into skull, axial skeleton, upper limb and lower limb. Each of these four categories can then be weighed separately to gain the percentage they comprise of the whole assemblage, following the removal of any non-human material.

Data for each fragment was collected as per the inhumation burials, with the exception of the fragments of bone that measure <2mm. This is due to time factors and the very limited amount of information that could be gleaned from such tiny fragments. However, the material was scanned for any recognisable fragments, such as tooth crowns. In addition, because cremation causes radical changes to the morphology and colour of bone, further information for these burials was recorded and photographed.

4.2.2.1 The Nature of Cremated Bone

Living bone is formed of 80% mineral (carbonate-hydroxyapatite crystals), and the remaining 20% of protein, in the form of collagen fibres (Millard, 2001). During the cremation process, the composition of bone is altered and experiences many morphological changes, such as, shrinkage, warping, longitudinal fissuring or fracturing, transverse fracturing, thumbnail fractures, patina or crazed fractures, and delamination. Colour changes to bone are also experienced during the cremation process. Each of these phenomena will be discussed below.

Shrinkage

When bone is cremated, there is a degree of shrinkage in the length and width of the hard tissue. This is due to changes in the crystal structure of the bone, in the form of increased crystallinity, with an overall greater crystal size and less porosity (Figueiredo *et al*. 2010: 2391), coupled with the release of the carbonate and water elements of the bone (Wang *et al*. 2010: 477). Different bones, even in the same skeleton, will be affected by different temperatures, especially in pyre cremation (McKinley and Bond 2001: 282).

Various experiments over the years have been carried out to discern the percentage of shrinkage during cremation, with differing results (Malinowski and Porawski, 1969; Dokladal, 1971; Herrmann 1976; Herrmann 1977a; Herrmann 1977b; Grupe and Herrmann, 1983; Bradtmiller and Buikstra, 1984); Buikstra and Swegle, 1989; Nelson, 1992; Hummel and Schutkowski, 1986; Holland, 1989; and Shipman *et al*., 1984). These researchers generally agree that there is minimal shrinkage in the first three stages of cremation, but during the final fusion stage, when temperatures exceed 1000°C, shrinkage can be as much as 37% (Thompson 2005: 7).

The reduction in size of bone once it has been cremated has an obvious impact on anthropological techniques, such as determining the age, sex and stature, as these techniques rely on metrical and morphological traits on unmodified bone. Until new techniques have been developed to correct for the amount of shrinkage experienced during cremation, age and sex determination of cremated remains need to be treated with caution (Thompson 2005: 7).

Warping

Warping on cremated bone (Figure 4.2A) was observed during experiments by Baby (1954), Binford (1963), Heglar (1984), Thurman and Willmore (1981), and Ubelaker (1978), but was not evident on dry cremated bone. It was therefore suggested that this phenomenon was caused by the muscle fibres shrinking, thereby bending the bone out of shape upon the application of extreme heat. However, Spennemann and Colley (1989: 61) disagreed, and put forward the idea that warping was due to the presence of heated trapped within the medullary cavity. Yet Thompson (2005:1) argues against both of these statements because he asserts that contracting muscles would not be capable of applying enough pressure to deform bone, and because bone is a porous material, it would not be possible to trap air within the medullary cavity. Instead, Thompson (2005: 1-2) favours the idea that warping is more likely to be caused by contractions of the periosteum, or to the differential distribution of collagen within the structure of bone. Subsequent research by Gonçalves *et al*. (2011), which involved the cremation of Portuguese adult skeletons that had been buried for a period of five years, showed that in a small number of cases, dry bone can produce warping and thumbnail fractures. Therefore, it is with caution that it can be inferred that any analysis of cremated bone exhibiting these phenomena, came from a corpse that was "fresh" when it put to the flames.

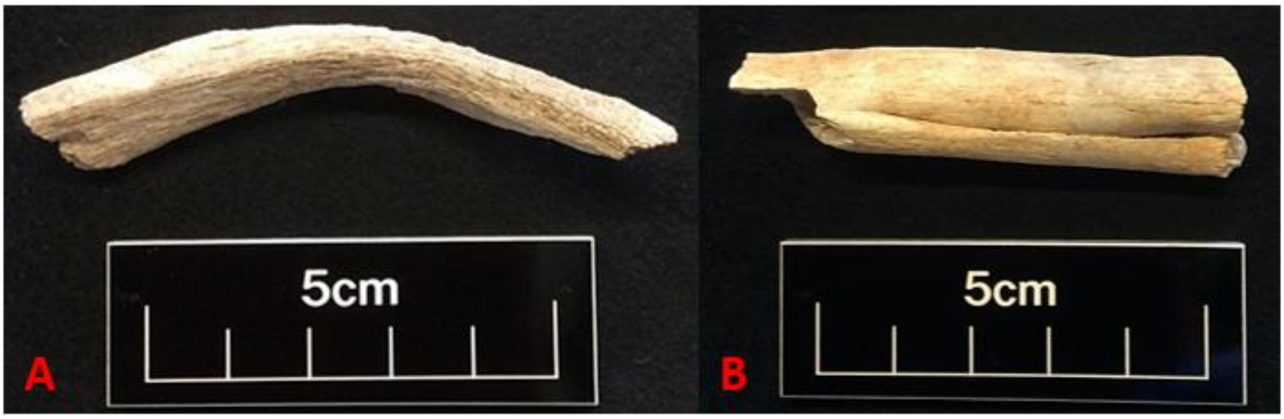


Figure 4.2: A - Cremated bone fragments from Chestnuts long barrow, Kent, showing warping B - Longitudinal fracture.

Longitudinal Fractures

Longitudinal fractures are the most prevalent of heat-induced fissures and occur in regular and predictable patterns, in particular, on long bones (Figure 4.2B). As the diaphysis increases in temperature, the bone shrinks, causing structural failure. Longitudinal fractures then develop which follow the grain of the bone, parallel to the osteon canals (Symes *et al*. 2008: 42).

Transverse Fracture

Transverse fractures (Figure 4.3A) transect the haversian canals in compact bone, and are relatively common in cremated remains due to the progress of flames running up the diaphysis of the long bones during burning (Symes *et al*. 2008: 42).

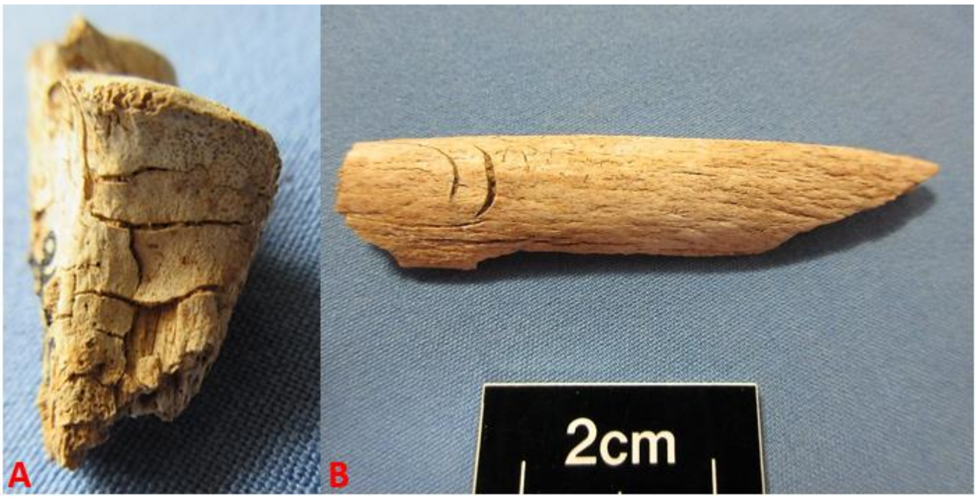


Figure 4.3: A - Cremated human bone from Hazleton North long barrow, Gloucestershire and Fromefield long barrow, Somerset showing transverse fracturing. B- Thumbnail fracturing.

Thumbnail Fractures

These fractures are the most distinctive in cremated remains and are caused by the heated bone cracking as soft tissue and periosteum shrink, pulling the surface of the bone (Figure 4.3B). Concentric rings can also be a manifestation of thumbnail fractures and appear in fossae, such as the olecron fossa of the humerus, or in areas of dense tissue, such as the popliteal space on the distal femur (Symes *et al*. 2008: 43).

Patina or Crazed Fractures

These fractures are the most superficial damage exhibited on cremated bone (Figure 4.4A), and are found on areas of flat bone, epiphyseal surfaces, and cranial bones which have received uniform levels of burning. The resulting appearance of the bone is that of a fine latticing, which resembles old china or an aged painting (Krogman, 1943b, cited in Symes *et al*. 2008: 42).

Delamination

Delamination (Figure 4.4B) is characterised by layers of cortical bone flaking away from the surface of the diaphysis, or by the separation of the ectocranial and endocranial surfaces of the cranium (Symes *et al.* 2008: 43).

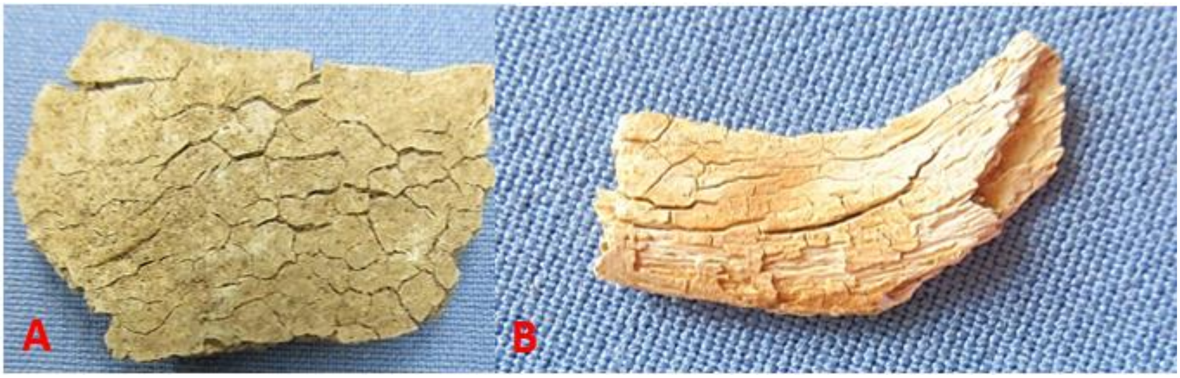


Figure 4.4: A - Cremated bone from Chestnuts long barrow exhibiting Patina. B – Cremated bone from Hazleton North long barrow exhibiting Delamination.

Colour Changes

The colour of cremated bone is very varied and is determined by several factors: the level of oxidation received during the cremation process; the temperature reached; and the availability of oxygen during the process (Shipman *et al*., 1984; Walker *et al*., 2008; McKinley, 1994). Shipman *et al*. (1984: 312-313) recorded a variety of colours on cremated animal bones that ranged from yellow, grey, black, to white, and stated that these changes can be linked directly to the amount of heat reached, although Maples and Browning's (1994) observations slightly differ in the order in which the colours appear – black, fading to dark gray, to a lighter gray, then finally to a fully calcined white (Maples and Browning 1994: 137). In addition, a range of colours may be evident on a single bone. Indeed, all of the colours listed may be present within a single cremation, due to differential temperatures, especially those experienced on a pyre (Mayne Correia 1997: 276; Heglar 1984: 149). However, Devlin and Herrmann (2015: 122) assert that the surface colour of burnt bone should not be used as the sole indicator of maximum temperature reached during the cremation processs, but used to infer the extent of thermal exposure.

Walker *et al.* (2008: 135) have demonstrated through experimental research that when the cremation process is hindered by lack of oxygen, the resultant colour of the bones will be affected. Indeed, recent research by Reidsma *et al*. (2016: 289) demonstrated that bone heated under reducing conditions (i.e. without oxygen) ranges in colour from white, to yellow, brown and black, without the wide range of colour experienced in combusted bone.

4.2.2.2 Estimation of Age at Death

The criteria for estimation of the age at death for cremation burials are mainly the same as the ones used for the inhumation burials, as features utilised for this calculation can still be seen on burnt bone. However, ageing by using cranial sutures is not feasible for these burials. This may be due to significant fragmentation experienced during the cremation process, or the premature separation of sutures already in the process of fusion, forced apart by the application of extreme temperatures, which may then indicate a younger age at death (Wahl 2015: 165). The procedure for evaluating MNI will be followed, ensuring that age differences, together with duplicate elements, are taken into account.

4.2.2.3 Determination of Sex

Determining the sex of cremated human remains is more problematic than for those who have been inhumed. Attributing sex to human remains depends on morphological and metrical differences between males and females. In the case of morphology, these features may still be apparent in cremated remains, such as the cranial features that are indicative of males (supra-orbital ridges, large mastoid process, square chin), and shape differences in the *os coxae*.

Where determination of sex is based on metrical data, such as long bone length, the shrinkage of bone during cremation will have an effect on the outcome. A study by Thompson (2005) states that shrinkage to cremated bone is minimal below 1000ºC, but at higher temperatures, shrinkage can be as much as 37%. Experimental studies have been carried out on pyre cremation burials and have concluded that temperatures can reach as high as 1000ºC, reducing the body to a oxidised state within three to ten hours (Pionteck 1976, cited in McKinley and Bond 2001: 24). Therefore, an average figure of 15% will be added to the relevant element studied.

4.2.2.4 Non-Metric Traits

Observation of non-metric traits is possible on cremated human remains, but are of limited value (McKinley 1989: 74). Therefore, these traits were not recorded for the cremation burials.

4.2.2.5 Trauma and Pathology

Evidence of trauma and pathology may still be observed on cremation burials and was recorded and photographed accordingly.

4.3 Stature

Stature was assessed using the total length of the long bones devised by Trotter (1970), with the caveat that the formulae were created from modern American adults, and may not therefore be entirely suitable for Neolithic populations. Where possible the femur was used to assess stature at the sites, as the lower limb bones give the most reliable results (Brothwell and Zakrzewski 2004: 33).

4.4 CPR and TPR

The crude prevalence rate (CPR) was given for the number of individuals affected by any disease/lesion etc. discussed in each chapter, out of the total number of individuals in this study. In this case that number was 305. For the discussion of dental disease, the CPR reflected the number of individuals with a dentition, which for this study was 192. The true prevalence rate (TPR) was given for each element discussed by side and zone where possible. For example, if the distal humerus was being discussed as the site of a lesion, then the number of whole left or right distal humeri was calculated, plus any fragmented distal humeri from that side with that zone. If an element can be assigned a sex, then the TPR for male or female for that bone was given, in order to even out the bias in the assemblage (due to more males than females in the collection). If the element belongs to a probable male or female, the TPR for sex was not be given.

4.5 Photography and CT Scanning

All photographs, unless otherwise stated, were taken by the author during the course of this study. The CT scans used in Chapter 7 (Infectious Disease) were taken by Ket Smithson at the Cambridge Biotomography Centre (Cambridge University) at the request of the author, using a micro CT scanner.

Chapter 5: Physical Characteristics

5.1 Completeness of Assemblages, Fragmentation, Taphonomic Alteration and Preservation

5.1.1 Completeness of Assemblages

Despite a disappointing number of extant individuals from many sites, six produced skeletons in varying proportions of completeness, from a scant 4.95% (48/626) to 73.8% (462/626) (Table 5.1), using the Zonation Method devised by Knüsel and Outram (2004), which states that a complete human skeleton has 626 zones. The reason why these individuals have been preserved in a better condition than previous human remains from other excavations may be due to more thorough and careful excavation methods. Three of the sites were excavated by Pitt Rivers in the mid nineteenth century (Handley 26, Handley 27, and Wor Barrow, all in Dorset), who was a very meticulous and careful excavator. Lanhill long barrow, Wiltshire, was re-excavated by Keiller and Piggott in 1938, who carefully recorded eight undisturbed individuals from a newly discovered chamber in the north-west of the barrow (Keiller and Piggott, 1938). The ground-breaking excavation at Hazleton North, Gloucestershire, which was conducted between 1979 and 1982, brought excavation standards up to a modern standard, in which each fragment of bone was recorded *in situ,* facilitating the possibility of reconstructing individuals from discrete piles of bones (Saville *et al*., 1990).

Table 5.1: Six sites with the most complete individual skeletons (in brackets), using the Zonation Method (Knüsel and Outram, 2004).

SITE	# ZONES PRESENT	% COMPLETENESS
Handley (26)	68	10.8%
Handley (27)	168	26.8%
Lanhill (# 1)	219	34.9%
Lanhill (# 2)	154	24.6%
Lanhill (# 3)	388	61.9%
Lanhill (# 5)	326	52.0%
Lanhill (# 6)	222	35.4%

Lanhill (# 7)	364	58.1%
Lanhill (# 8)	201	32.1%
Wor Barrow (# 1)	134	21.4%
Wor Barrow (# 2)	119	19.0%
Wor Barrow (# 3)	120	19.1%
Wor Barrow (# 4)	148	23.6%
Wor Barrow (# 5)	142	22.6%
Wor Barrow (# 6)	98	15.6%
Wor Barrow (# 8)	103	16.4%
Hazleton (A)	252	40.2%
Hazleton (# 1)	462	73.8%
Hazleton (C)	168	26.8%
Hazleton (D)	88	14.0%
Hazleton (E)	48	7.6%
Hazleton (F)	86	13.7%
Hazleton (G)	118	18.8%
Hazleton (H)	64	10.2%
Hazleton (# 2)	439	70.1%
West Kennet EU 1.5.140	432	69.0%
West Kennet IX	190	30.3%
West Kennet X	192	30.7%
West Kennet EU 1.5.142	193	30.8%
West Kennet II	31	4.95%

5.1.2. Fragmentation

The assemblages from the 42 sites were highly fragmented, except those from Bratton Camp, Figheldean Down, Tilshead Old Ditch (all in Wiltshire), and Gatcombe Lodge, Gloucestershire, which were composed of whole elements only (Table 5.2).

Table 5.2: % fragmentation and complete elements for the sites studied.

Site	# Whole Elements	# Incomplete/fragments	% Whole	% Fragmented
Avening	0	7	0%	100%
Avenis (Smart's Farm)	14	22	38.8%	61.2%
Belas Knap	11	32	25.6%	74.4%
Bown Hill (Woodchester)	3	21	12.5%	87.5%
Bratton Camp	2	0	100%	0%
Broadsands	33	389	7.8%	92.2%
Chestnuts	3	4264	0.07%	99.93%
Figheldean Down (31)	2	0	100%	0%
Fittleton Down (5)	1	2	33%	67%
Fromefield	406	666	37.8%	62.2%
Fyfield (Giants Grave)	2	2	50%	50%
Gatcombe Lodge	2	0	100%	0%
Giant's Hills (Skendleby I)	219	197	52.6%	47.4%
Haddenham	47	2418	1.9%	98.1%
Handley 26	2	76	2.56%	97.4%
Handley 27	21	1	95.5%	4.5%
Hazleton North	2889	18676	13.4%	86.6%
Hetty Pegler's Tump (Uley)	2	21	8.7%	91.3%
Horton Down (Bishops Cannings 91)	0	4	0%	100%
Imber (Bowls Barrow)	3	5	37.5%	62.5%
Jackbarrow	1	4	20%	80%
Kings Playdown (Heddington 3)	4	2	66.6%	33.4%
Lamborough Banks (Ablington)	0	2	0%	100%
Lanhill	347	61	85%	15%
Littleton Drew (Lugbury)	1	23	4.2%	95.8%
Luckington (Giants Cave)	252	1231	16.6%	83.1%
Millbarrow	66	526	11.1%	88.9%
Netheravon Down (6)	0	4	0%	100%
Norton Bavant	2	13	13.3%	86.7%

Nympsfield	4	23	14.8%	85.2%
Oldbury Hill	0	4	0%	100%
Randwick	2	2	50%	50%
Rodmarton	22	42	34.4%	65.6%
Stonehenge (Amesbury 14)	0	4	0%	100%
Stoney Littleton	7	21	25%	75%
Tilshead East (7)	0	10	0%	100%
Tilshead Lodge	0	4	0%	100%
Tilshead Old Ditch	2	0	100%	0%
West Tump (Cranham)	0	2	0%	100%
Winterbourne Monkton	8	31	20.5%	79.5%
Wor Barrow	77	119	39.3%	60.7%
West Kennet	1232	1900	39.3%	60.7%
TOTAL	**5689**	**30831**		

The percentage of fragmentation (excluding loose teeth) for the remaining sites ranged from 100% to 4.5% (1/22), with the degree of fragmentation ranging from <5mm, to 80mm+ (which includes elements that have zones missing).

5.1.3 Taphonomic Alteration

The term “taphonomy” was coined by Efremov, a Russian palaeontologist, to describe the laws which affect embedding or burial – all of the processes that affect skeletal material from the time of deposition, to recovery (Efremov 1940: 85). By studying the taphonomy of burials, it is possible to build up a picture of the funerary rites and bone assemblage formation processes. Table 5.3 below details the main taphonomic factors: erosion; weathering; root damage; and post-mortem fracturing (inflicted on dry bone either prior to excavation, or during excavation/curation) exhibited at the 42 sites studied.

Table 5.3: Taphonomic factors affecting human remains at the sites.

SITE	EROSION	WEATHERING	ROOT ACTION	POST-MORTEM FRACTURES
Avening	✓	X	X	✓
Avenis (Smart’s Farm)	✓	X	X	✓
Belas Knap	✓	✓	X	✓
Bown Hill (Woodchester)	✓	X	X	✓

Bratton Camp	✓	✓	X	✓
Broadsands	✓	X	X	✓
Chestnuts	✓	X	X	✓
Figheldean Down (31)	✓	X	X	✓
Fittleton Down (5)	✓	X	✓	✓
Fromefield	✓	✓	X	✓
Fyfield (Giants Grave)	✓	✓	X	✓
Gatcombe Lodge	✓	X	X	✓
Giant's Hills (Skendleby I)	✓	✓	X	✓
Haddenham	✓	✓	X	✓
Handley 26	✓	X	✓	✓
Handley 27	X	X	X	✓
Hazleton North	✓	✓	✓	✓
Hetty Pegler's Tump (Uley)	✓	✓	X	✓
Horton Down (Bishops Cannings 91)	✓	X	X	✓
Imber (Bowls Barrow)	✓	✓	X	✓
Jackbarrow	✓	✓	X	✓
Kings Playdown (Heddington 3)	✓	✓	X	✓
Lamborough Banks (Ablington)	X	X	X	✓
Lanhill	✓	✓	X	✓
Littleton Drew (Lugbury)	✓	✓	X	✓
Luckington (Giants Cave)	✓	✓	X	✓
Millbarrow	✓	✓	X	✓
Netheravon Down (6)	✓	✓	X	✓
Norton Bavant	✓	✓	X	✓
Nympsfield	✓	✓	X	✓
Oldbury Hill	✓	✓	X	✓
Randwick	✓	✓	X	✓
Rodmarton	✓	✓	X	✓
Stonehenge (Amesbury 14)	✓	X	X	✓
Stoney Littleton	✓	X	X	✓
Tilshead East (7)	✓	X	X	✓
Tilshead Lodge	✓	X	✓	✓
Tilshead Old Ditch	✓	X	X	✓
West Tump (Cranham)	X	X	X	✓
Winterbourne Monkton	✓	✓	X	✓
Wor Barrow	✓	✓	X	✓
West Kennet	✓	✓	X	✓

Surface modification of bone, caused by such agents as erosion, staining, abrasion, or concretion, may give clues to the burial environment. Repeated movement by human agency (often a facet of Neolithic burial rites) or water, may cause bones to become eroded. Abrasion may occur when the surface of bone is subjected to the scouring effect of fine sediments, and where the environment is damp or wet, concretion may occur, covering the bones in a solid layer of silty material. Many of the human remains from Haddenham long barrow, Cambridgeshire, were covered in a red silty concretion, a mixture of sand cemented by iron salts (Lee 2006: 145). Such was the degree of concretion on the bones, that some elements were unidentifiable, whilst it was impossible to identify the topography of some other elements (Figure 5.1). Staining may occur on bone due to the mineral content of the burial context, or from metal grave goods, not a phenomenon likely to be found in Neolithic bone assemblages.

Figure 5.1: Mid and distal diaphysis of a left humerus with concretion (detail on the right) from Haddenham long barrow, Cambridgeshire.

Root damage to human remains is a problem when assessing assemblages. The collections of bones from 12 of the long barrows analysed for this study contained elements that had been affected by root damage. The scale of damage seen varied from slight and patchy surface erosion (Grade 1, according to the scale proposed by McKinley, 2004: 16), to heavy erosion across the whole surface, masking the normal topography, with some modification of profile (Figure 5.2). Not only does the root damage affect the strength of the bone, but depending on the scale of the erosion, masks signs of a pathological nature, and in the case of the example below, totally obliterates the cranial sutures, which aid with ageing the individual.

Figure 5.2: Cranium from Figheldean Down long barrow, Wiltshire, with Grade 5 erosion caused by root damage.

Understanding fracture patterns on bone is key to determining whether the fracture was experienced peri-mortem, or shortly after death, when the bone was still plastic (green), or long after death, when the bone had become dry and lost much of its organic content. Dry fractures may result from handling of bone long after death, as is the practice evidenced at some Neolithic long barrows, where bones are either pushed aside to make way for subsequent burials, or sorted into piles according to element, or most commonly, during or after excavation. Dry fracture surfaces exhibit a rough texture, which contracts to the colour of the surrounding bone, and forms right-angled edges (Byers 2010: 287). Fresh, or green fractures, may be caused by accident, violence, or scavenging by animals, and are characterised by smooth sharp edges, which are the same colour as the adjacent bone, and form helical, radiating, or concentric fracture lines with the surrounding bone (Galloway *et al*. 2014b: 50-51).

Most of the fractures recorded in the current study were of the dry type, and probably occurred during excavation or curation. Those that were deemed to be fresh fractures were likely caused by trauma, and will be fully reported on in Chapter 10. However, the re-analysis of the vast assemblage from Hazleton North long barrow revealed fracture patterns on some of the bones that occurred when fresh, and coupled with other evidence, suggest multiple cases of excarnation - a funerary practice that we have little evidence for in most long barrows in southern Britain.

Hazleton North long barrow, Gloucestershire, is a Cotswold-Severn long barrow, with two opposing lateral chambers – one on the north side, and the other on the south. Sixty-three bones from the assemblage exhibited extensive gnawing (Appendix 3), 57 of which were considered to have been chewed by canids, the rest by small mammals. However, in the report on the human remains from the tomb by Rogers (1990), there is a brief mention of 15 bones that exhibited gnawing by animals, nine of which were considered by the author to have been “fresh” (Rogers 1990: 182). This is certainly the case with a right adult fibula, # 6491 (shaded red in Appendix 3), as Rogers points out, the bone has been covered in a concretion, which has been gnawed through to get to the bone below, but the other eight bones do not look any different from those considered (in the recent analysis) to be ancient damage.

The elements that exhibited large gnawing marks include: humerus; radius; ulna; scapula; femur; tibia; fibula; calcaneus; metatarsal; phalanx; rib; clavicle; and mandible. Ninety-two percent of the bones affected were excavated from the north chamber and passage, and the remaining 8% from the south chamber and passage. At least six individuals (based on the presence of a gnawed left fibula) experienced chewing by canids, representing 15% of the entire assemblage from this tomb (6/41).

The evidence for scavenging by canids was exhibited in helical fractures, longitudinal fractures, gnawing marks (on diaphyses and crenulated edges), tooth furrowing, tooth notching and puncture marks (Figures 5.3 and 5.4) as detailed by Binford (1981) and Young *et al.* (2015). The puncture marks range in size from 2.5 mm supero-inferiorly and 1.9mm medio-laterally, to 3.5mm supero-inferiorly and 4.4mm medio-laterally, indicative of the size of the penetrating canines of larger mammals, such as canids (Lyman 2001: 214; McKinley 2008: 494). Furthermore, Figure 5.5 shows damage to two ribs consistent with the powerful biting motion of the canines and incisors of dogs, in the process of piercing flesh (A. Outram, pers. comm.). The right rib (Figure 5.5C and D) exhibits a semi-circular bite mark that is consistent with the bite marks left by canids reported by Murmann *et al*. (2006: 859). Additionally, the measurements of the bite mark on the inferior margin of the rib shaft (24.6mm medio-laterally and 12.4mm supero-inferiorly) are within the ranges given by Murmann *et al*. (2006: 858) for the maxillary mesial bone height for dogs (1.3-3.3cm) and gray wolves (2.3-3.0cm).

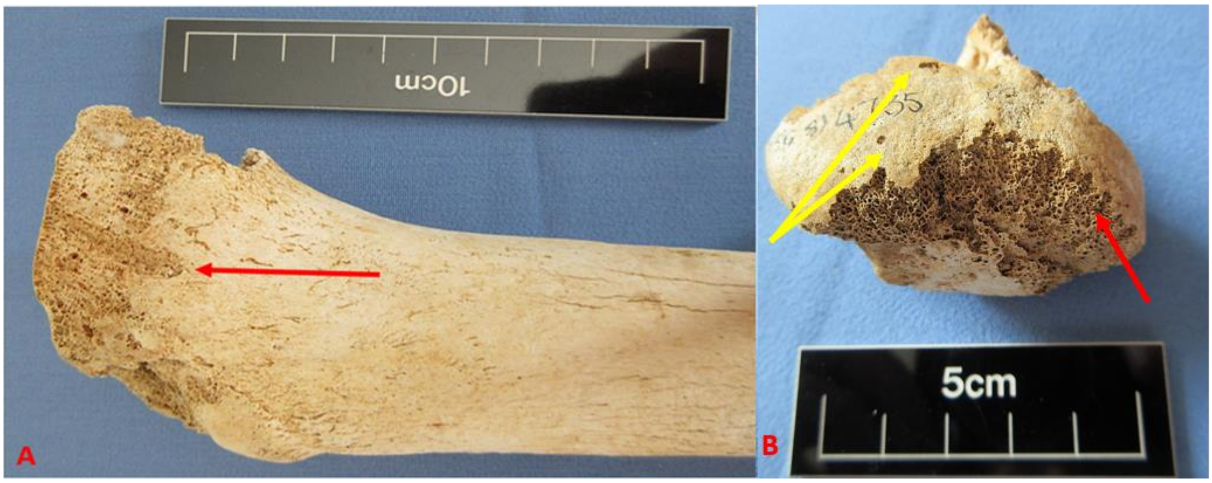


Figure 5.3: A – Right tibia from Skeleton C, from Hazleton North long barrow with evidence of tooth furrowing (measuring 21.7mm supero-inferiorly and 4.4mm medio-laterally) on the proximal end. B – Crenulated edges on the medial condyle of a left femur (# 4735) (red arrows), puncture marks (yellow arrows).

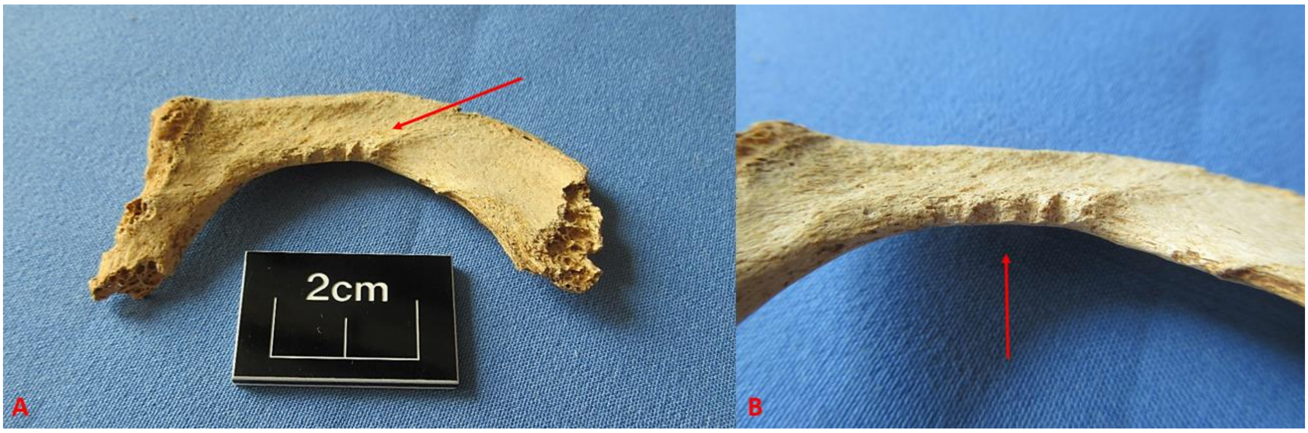


Figure 5.4: A - Left first rib (# 6108) from Hazleton North long barrow with four parallel tooth gouges on the internal midshaft (measuring 13.6mm medio-laterally and 2.9mm supero-inferiorly). B – Detail.

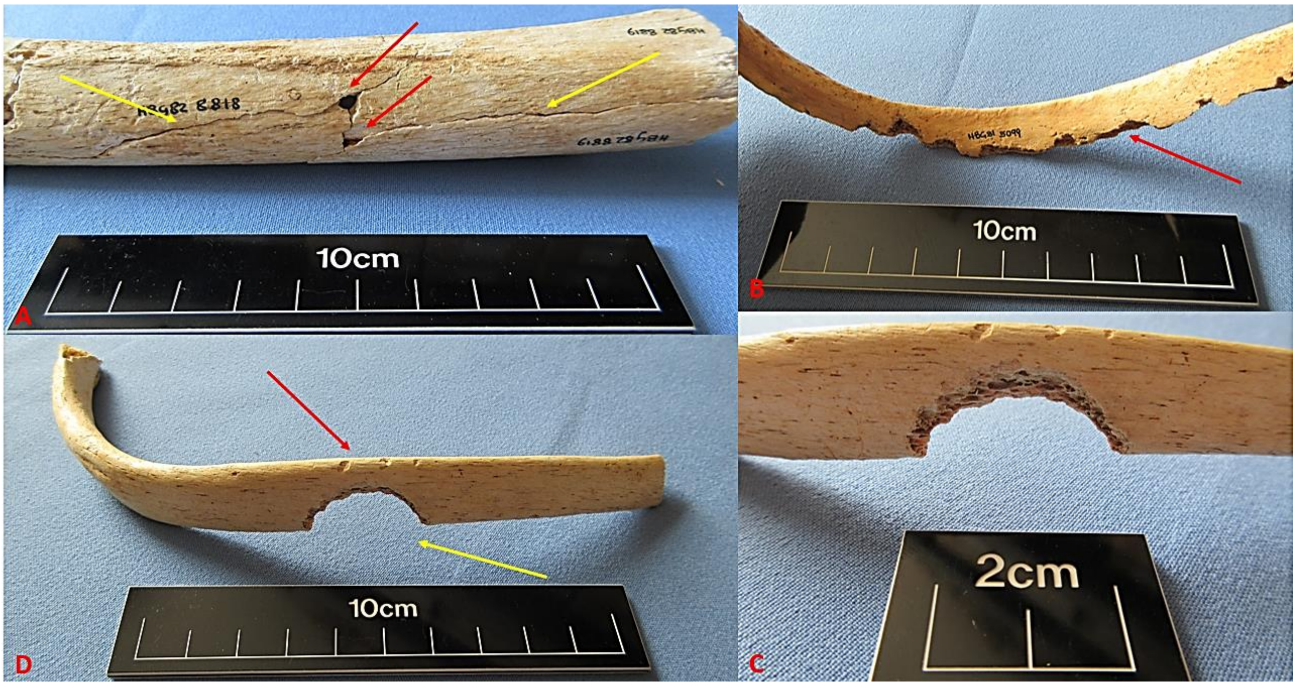


Figure 5.5: A – right femoral diaphysis with puncture marks, measuring 2.7mm supero-inferiorly and 2.6mm medio-laterally (red arrows) and longitudinal fractures (yellow arrows. B – Left rib # 5099 with tooth notching of the rib margin. C – Right rib # 6489 with bite mark to the inferior margin. D – Detail.

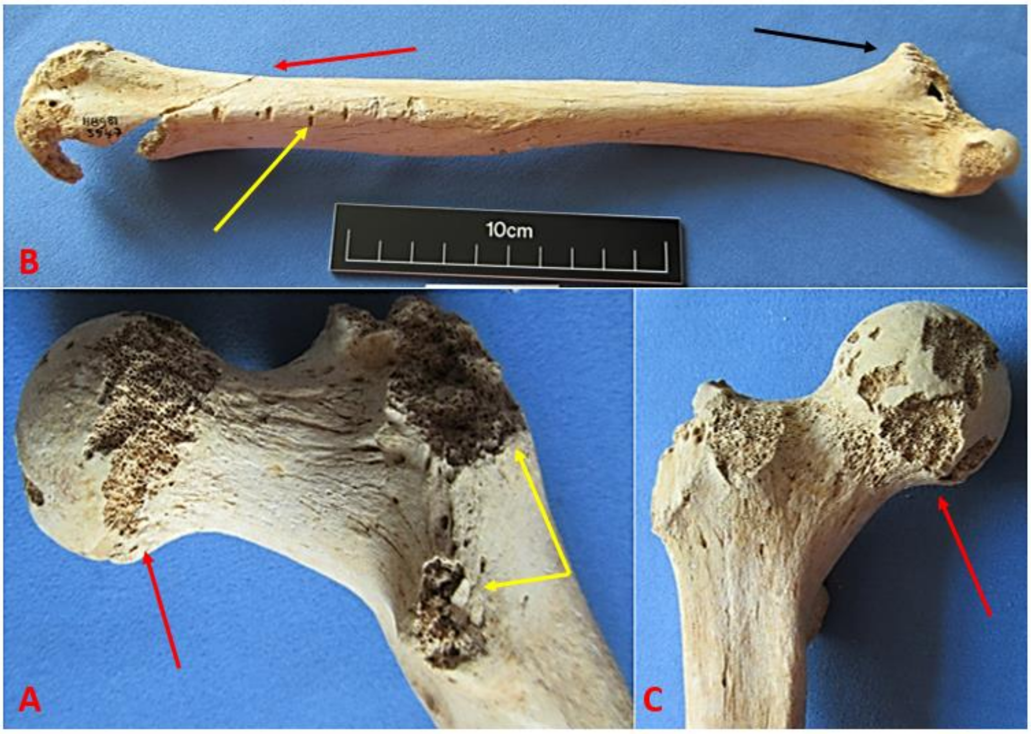


Figure 5.6: Individual C from Hazleton North long barrow. A - Right femur with chewed head and greater and lesser trochanters (posterior views). B –Right humerus with helical fracture (red arrow), tooth marks (yellow arrow) and chewed distal end (black arrow).C- Anterior view of right femur.

One individual in particular, Skeleton C, exhibited extensive gnawing to all of the long bones present and to four of the left tarsals. In addition, the right humerus exhibits extensive chewing and a helical fracture on the proximal end (Figure 5.6), together with crenulated edges on the right proximal tibia, and chewing of the right femoral head and the greater and lesser trochanters (Figure 5.6). Moreover, all of the long bones were weathered.

The fact that the bones from Individual C and most of the other elements from different contexts, are both weathered and seemed to be gnawed by either wolves or dogs, strongly suggests that excarnation was being practiced by the community who used the long barrow at Hazleton North. According to Behrensmeyer (1978: 154), in order for bone to become weathered, it must by definition, be exposed to the elements and subjected to heat, cold, wet or dry environments. All of the bones that were weathered, were deemed to represent Stage 1 in Behrensmeyer's scheme (cracking parallel to fibre structure, i.e. longitudinal in long bones) (Behrensmeyer 1978: 151). This stage equates to a period of exposure of between a few days, and up to three years

(Behrensmeyer 1978: 157). The pattern of skeletal destruction experienced by this individual would seem to follow that given by Binford (1981) as behaviour carried out by wolves at kill sites, where the bones were subjected to "some furrowing, relatively common puncture marks, and some crenuelated edges" (Binford 1981: 49). Given that the corpse retained all of its limbs, except for the right radius, would indicate limited access to the remains, either spatially or temporally, otherwise longer exposure to carnivorous animals would result in these large and heavy "joints" being removed from the site and taken elsewhere where a higher rate of consumption could take place (Haglund 1997: 379). A certain amount of disarticulation took place with this individual as the proximal and distal ends of some long bones were chewed. Especially noteworthy is the fact that the right femoral head has been chewed in a pattern associated with scavenging canids, and by necessity would have needed to be disarticulated from the pelvis in order to gain access to it. Haglund's work on the post mortem involvement of dogs with human remains suggests that if this stage of disarticulation has been reached, a period of between two to eleven months has passed since the body was exposed to outside interference (Haglund 1979: 372). Therefore, given the stage of weathering to the bones, the extent of damage by canids, whether wolves, dogs, or even foxes, suggests a scenario where bodies were exposed to the elements and scavenging agents for a limited amount of time, before being collected and placed within the tomb.

Despite the paucity of human remains from Bown Hill (Woodchester) long barrow, Gloucestershire, there is also evidence here of scavenging by canids, seen on a right femur (Figure 5.7). The femoral head has the distinctive chewing pattern left by scavenging canids, and both the greater and lesser trochanters have been chewed. The diaphysis has also suffered a helical fracture, consistent with assault when fresh, and is deemed to be weathered (Stage 1).

Figure 5.7: A - Right femur from Bown Hill (Woodchester) long barrow, Gloucestershire, with helical fracture, and gnawed femoral head, greater and lesser trochanters (posterior view). B-Anterior view.

This important new data concerning scavenging of human remains by canids, as a by-product of excarnation, adds to a small corpus of information from other long barrows in southern Britain, where this funerary rite would seem to have been practiced. Smith's (2006) re-analysis of the human remains from Adlestrop long barrow, Gloucestershire revealed that each of the seven individuals interred within the monument had been scavenged by canids. Similarly, a reappraisal of the assemblage from Bowls Barrow, Wiltshire asserted that 5.4% of the bones had also been scavenged (Smith and Brickley 2009: 42). Furthermore, the re-analysis of the assemblage from Parc Le Breos in Wales found evidence of scavenging by carnivores (Whittle and Wysocki 1998: 158).

The extent to which excarnation may have been a common feature of Neolithic funerary practice may be severely under-represented in assemblages, due to the fact that many lack long bones and in many cases, are only represented by crania, which tend to be less desirous to scavengers, probably due to the lack of meat.

5.2 Burial Practices

The extent of fragmentation exhibited in most of the collections of bones from the sites, which was commonly noted at the time of excavation, would seem to imply that a degree of manipulation of the assemblage was undertaken during the lifetime of the monuments (Colt Hoare 1812: 21). Consequent collection and curation of the human remains have probably caused further breakage. It was possible to infer the insertion of primary burials into the tombs from the excavation reports, but only in two cases. An adult male (Skeleton # 1) from Hazleton North long barrow was the last burial to be inserted into the north passage of the monument, before the entrance was blocked off (Saville *et al*. 1990: 103). At Lanhill long barrow, another adult male (EU.1.5.109) was also the last burial to be inserted into the north-west chamber (Keiller and Piggott 1938: 127).

The rite of cremation was solely practiced at Chestnuts long barrow, but there was some evidence of cremated human remains at seven other sites, which also contained inhumations (Table 5. 4). However, it is clear from the weight of the cremation deposits that they do not contain the remains of a whole corpse, which at Spong Hill, weighed an average of 812.4g (McKinley 1994a: 11). These scant deposits may therefore perhaps represent a token deposit, as collection of all of the burnt bones from the pyre was not deemed necessary (McKinley 1989: 71). As detailed in Section 5.1.3, excarnation was carried out at least two new sites in the current study, at Hazleton North long barrow, and at Bown Hill long barrow.

Table 5.4: Sites with both inhumation and cremation burials.

Site	Weight of Cremation (g)	Colour	Features of Cremated Bone	Bones Affected
Broadsands	**74.22**	**White**	**Transverse fissuring, patina**	**Cranium** **Unidentified fragments.**
Fromefield	**79.22**	**White** **White/blue**	**Longitudinal fissuring, transverse fissuring, thumbnail fissuring**	**Cranium, long bone fragments, radius**
Haddenham	**147.06**	**White** **white/black** **Grey/blue**	–	**Cranium, unidentified, mandible, phalanges, teeth**

Hazleton North	**187**	**White** **Blue/black** **Blue/white** **Blue** **Grey**	**Longitudinal fissuring, transverse fissuring, patina, shrinkage**	**Unidentified,** **Cranium, rib, vertebral fragments, ulna**
Luckington	**116.74**	**White** **White/blue** **Black**	**Transverse fissuring**	**Unidentified, cranium, rib, vertebral fragments**
Stoney Littleton	**14.39**	**White/grey** **Black/blue**	**Longitudinal fissuring**	**Cranium, rib, fibula, long bone fragment**
West Kennet	**26.95**	**White** **Grey/white** **Black**	**Longitudinal fissuring, thumbnail fissuring, patina**	**Long bone fragments**

5.3 Minimum Number of Individuals Within Assemblages

The minimum number of individuals represented in each assemblage was assessed by recording the most abundant zone or element present, after sorting by side and by age. The lowest MNI encountered at eleven sites was one, and the highest was 42. Eight of the sites with an MNI of one, originally contained more individuals which have consequently been lost, as previously discussed. However, three of the sites (Figheldean Down and Kings Play Down, both in Wiltshire, and Lamborough Banks, Gloucestershire) reportedly held only one skeleton each at the time of excavation. Upon re-examination, the individuals from these three sites were greatly diminished and were only represented by: a cranium and mandible; cranium, mandible, and three long bones; and two long bones respectively. The sites at which there were more than ten individuals identified, but unfortunately were represented solely by crania and mandibles were Belas Knap, Gloucestershire; Littleton Drew, Norton Bavant, and Winterbourne Monkton, Wiltshire. Rodmarton long barrow contained mostly crania, mandibles and some long bones and vertebrae. Hazleton North, West Kennet and

Fromefield long barrows produced highly fragmented assemblages, which nevertheless, contained most skeletal elements.

5.4 Demography

5.4.1 Age at Death Profiles

Table 5.5 below lists the 42 sites analysed and the numbers of adults, juveniles (ages 12- 20), and children (up to age 12) that were able to be assigned an age category. The total number of adults identified was 223, and were present at each site, making a total of 73% (223/305) of all individuals assessed (Figure 5.8), and in 23 cases, adults were the only occupants of the long barrow. At the remaining sites, juveniles were under-represented, at most making up 33% (2/6) of the assemblage (Giant's Hills, Skendleby I), and representing only 5% (16/305) of the population in total. The children, however, were much more abundant, and made up 41% (17/41) of the assemblage at Hazleton North, 38% (16/42) at West Kennet, and 50% (1/2) at Stoney Littleton, but overall this category represents only 22% (66/305) of the total.

Table 5.5: Sites with age at death categories.

SITE	Adults	Juveniles	Children < 12
Avening	**3**	**0**	**0**
Avenis (Smart's Farm)	**3**	**1**	**1**
Belas Knap	**16**	**0**	**3**
Bown Hill (Woodchester)	**3**	**0**	**0**
Bratton Camp	**1**	**0**	**0**
Broadsands	**4**	**1**	**1**
Chestnuts	**5**	**0**	**2**
Figheldean Down (31)	**1**	**0**	**0**
Fittleton Down (5)	**1**	**0**	**0**
Fromefield	**10**	**3**	**5**
Fyfield (Giants Grave)	**2**	**0**	**0**
Gatcombe Lodge	**1**	**0**	**0**
Giant's Hills (Skendleby I)	**4**	**2**	**0**
Haddenham	**4**	**0**	**1**
Handley 26	**1**	**0**	**0**

Handley 27	**1**	**0**	**0**
Hazleton North	**22**	**2**	**17**
Hetty Pegler's Tump (Uley)	**5**	**0**	**0**
Horton Down (Bishops Cannings 91)	**1**	**0**	**0**
Imber (Bowls Barrow)	**5**	**0**	**0**
Jackbarrow	**3**	**0**	**0**
Kings Playdown (Heddington 3)	**1**	**0**	**0**
Lamborough Banks (Ablington)	**1**	**0**	**0**
Lanhill	**6**	**1**	**1**
Littleton Drew (Lugbury)	**12**	**0**	**0**
Luckington (Giants Cave)	**7**	**1**	**3**
Millbarrow	**3**	**1**	**4**
Netheravon Down (6)	**2**	**0**	**0**
Norton Bavant	**11**	**0**	**1**
Nympsfield	**7**	**0**	**2**
Oldbury Hill	**3**	**0**	**0**
Randwick	**2**	**0**	**1**
Rodmarton	**9**	**1**	**2**
Stonehenge (Amesbury 14)	**3**	**0**	**0**
Stoney Littleton	**1**	**0**	**1**
Tilshead East (7)	**6**	**0**	**2**
Tilshead Lodge	**2**	**0**	**0**
Tilshead Old Ditch	**1**	**0**	**0**
West Tump (Cranham)	**1**	**0**	**0**
Winterbourne Monkton	**18**	**1**	**3**
Wor Barrow	**6**	**1**	**0**
West Kennet	**25**	**1**	**16**
TOTAL	**223**	**16**	**66**

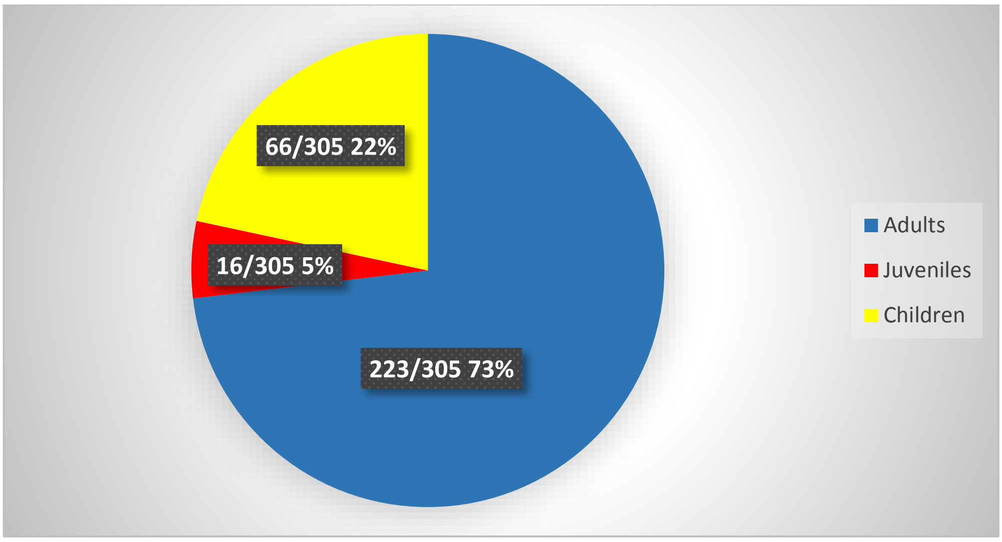


Figure 5.8: Chart showing proportion of each age category for all sites together.

The percentage of juveniles and children represented within the assemblages overall is very low – lower, in fact, than the figure discussed by Lewis of 30% for child mortality rates in pre-industrialised countries (Lewis 2007: 22). It is therefore tempting to assign the discrepancies in the survival of bone from children to the delicate nature of these diminutive elements, and in fact, this was the case in a study by Bello and Andrews (2006). However, at the sites where there is a generous representation of sub adult bones (for example, Hazleton North and West Kennet) the immature human remains are generally taphonomically similar to those of the adults. One reason for under-representation may be an excavator's unfamiliarity with the bones of children, which were then either unrecovered, or not sieved, and consequently lost. However, there is the real possibility that the bones of children were not deemed significant enough to be kept by the excavator. The long barrow at Littleton Drew (Lugbury), for example, was reported as having contained the remains of six children, two juveniles, and 18 adults (Thurnam 1857a: 172). Interestingly, only 13 of these individuals are extant, represented only by crania and mandibles, but none of them are children or juveniles.

Table 5.6 below shows the age ranges used when assessing the adult human remains from the long barrow sites. The total number of adults at each site correspond to the total of the separate age categories at only 20 sites (for example, six adults were excavated from Wor Barrow, Dorset, and these were split into 2 young adults and four middle adults). However, at the remaining 22 sites, the numbers do not correspond, and in 77 cases, the individuals could not be assigned to a specific adult age category. The reason for this discrepancy is that the MNI for the adults was based on the most common element or zone within the assemblage (according to side), and it is not possible to use these elements to age individuals. For example, the MNI for the adults at Hazleton North long barrow was calculated on 21 left 1st metatarsals (plus one cremation). The criteria for ageing the adults for this site was based upon mandibular dental attrition, plus five ossified laryngeal cartilages, which are symptomatic of an age exceeding 65 years (Gray 1977: 958). Furthermore, there were not sufficient data from the *ossa coxae* from the assemblage to assist in this endeavour. The 19 sites that have corresponding adult numbers to separate age categories, consist entirely of crania and mandibles, with suitable dentition to aid ageing, or more complete skeletons with complimentary elements to assist this.

Table 5.6: Categories assigned to adult age estimation.

SITE	Young Adult 20-35 years	Middle Adult 35-50 years	Old Adult 50+ years	Un-aged Adult
Avening	1	1	1	0
Avenis (Smart's Farm)	0	2?	1?	0
Belas Knap	1	9	0	6
Bown Hill (Woodchester)	?	?	?	3
Bratton Camp	1	0	0	0
Broadsands	?	?	?	4
Chestnuts	?	1	?	4
Figheldean Down (31)	0	1	0	0
Fittleton Down (5)	0	1	0	0
Fromefield	1	1	?	8
Fyfield (Giants Grave)	1	1	0	0
Gatcombe Lodge	1	0	0	0
Giant's Hills (Skendleby I)	4	0	0	0
Haddenham	1	?	?	3
Handley 26	0	1	0	0
Handley 27	0	1	0	0
Hazleton North	5	9	5	3
Hetty Pegler's Tump (Uley)	0	2	0	3

Horton Down (Bishops Cannings 91)	?	?	?	1
Imber (Bowls Barrow)	2	0	2	1
Jackbarrow	0	2	1	0
Kings Playdown (Heddington 3)	0	1	0	0
Lamborough Banks (Ablington)	?	?	?	1
Lanhill	4	0	2	0
Littleton Drew (Lugbury)	4	1	0	7
Luckington (Giants Cave)	4	1	?	2
Millbarrow	?	?	?	3
Netheravon Down (6)	1	1	0	0
Norton Bavant	3	1	0	7
Nympsfield	2	0	2	3
Oldbury Hill	0	3	0	0
Randwick	2	?	?	0
Rodmarton	4	2	1	2
Stonehenge (Amesbury 14)	1	1?	1	0
Stoney Littleton	?	?	?	1
Tilshead East (7)	1	?	?	5
Tilshead Lodge	1	1	0	0
Tilshead Old Ditch	0	0	1	0
West Tump (Cranham)	?	?	?	1
Winterbourne Monkton	8	4	3	3
Wor Barrow	2	4	0	0
West Kennet	13	3	3	6
Total for each category	69	54	23	77
TOTAL	223			

5.4.2. Attribution of Sex Within Assemblages

Table 5.7 below shows the numbers of adult individuals from all sites (n=223), separated into male and female where feasible. Possible male and possible female were listed separately. Where attribution of sex was not possible, the individual was assigned the indeterminate category. Figure 5.9 shows the percentage of each sex assigned.

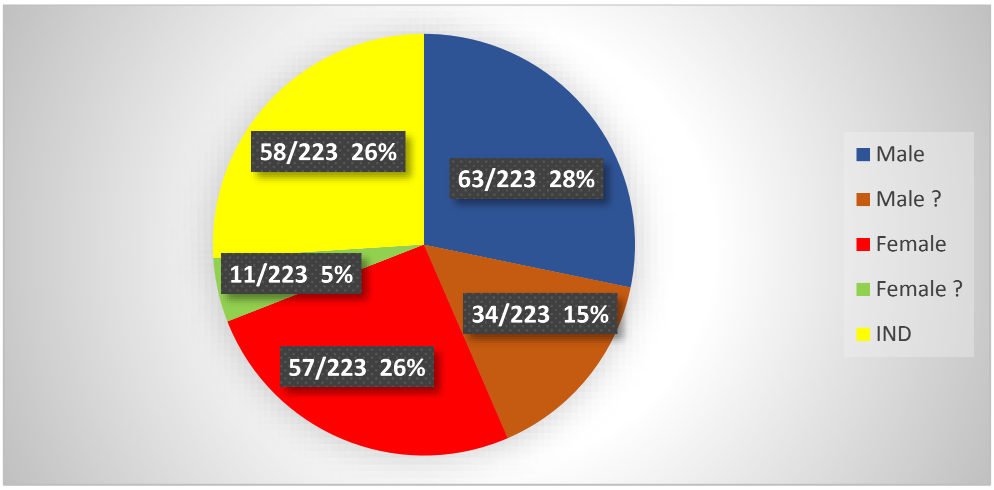


Figure 5.9: Chart showing percentage of males and females at sites.

Table 5.7: Numbers of male, possible male (in brackets), female, possible female (in brackets) and indeterminate adults at all sites.

SITE	Adult Male	Adult Female	Adult IND
Avening	0	1?	2
Avenis (Smart's Farm)	1	1?	1
Belas Knap	5 (2?)	8 (1?)	0
Bown Hill (Woodchester)	1	0	2
Bratton Camp	0	1	0
Broadsands	3	0	1
Chestnuts	1	0	4
Figheldean Down (31)	0	0	1
Fittleton Down (5)	(1?)	0	0
Fromefield	3 (2?)	2	3
Fyfield (Giants Grave)	2	0	0
Gatcombe Lodge	1	0	0
Giant's Hills (Skendleby I)	2	2	0
Haddenham	1	1	2
Handley 26	0	1	0
Handley 27	1	0	0
Hazleton North	5 (1?)	3	13
Hetty Pegler's Tump (Uley)	1 (1?)	(1?)	2
Horton Down (Bishops Cannings 91)	0	0	1
Imber (Bowls Barrow)	2	1	2

Jackbarrow	**1**	**2**	**0**
Kings Playdown (Heddington 3)	**1**	**0**	**0**
Lamborough Banks (Ablington)	**0**	**0**	**1**
Lanhill	**3**	**2**	**1**
Littleton Drew (Lugbury)	**(5?)**	**3**	**2**
Luckington (Giants Cave)	**(1?)**	**2**	**4**
Millbarrow	**1**	**0**	**2**
Netheravon Down (6)	**(1?)**	**0**	**1**
Norton Bavant	**2 (3?)**	**5 (1?)**	**0**
Nympsfield	**1 (5?)**	**1**	**0**
Oldbury Hill	**1**	**1, (1?)**	**0**
Randwick	**2**	**0**	**0**
Rodmarton	**(1?)**	**2 (2?)**	**4**
Stonehenge (Amesbury 14)	**2**	**1**	**0**
Stoney Littleton	**0**	**0**	**1**
Tilshead East (7)	**(3?)**	**1, (2?)**	**0**
Tilshead Lodge	**2**	**0**	**0**
Tilshead Old Ditch	**0**	**1**	**0**
West Tump (Cranham)	**0**	**0**	**1**
Winterbourne Monkton	**5 (6?)**	**7**	**0**
Wor Barrow	**3**	**3**	**0**
West Kennet	**8 (2?)**	**7 (1?)**	**7**
Total of column	**63 (34?)**	**57 (11?)**	**58**
TOTAL	**223**		

The number of adults in each category were not significantly different, which may represent an almost equal distribution of sexes between the adults, or maybe this is due to the fact that 26% could not be assigned a sex. Problems with fragmentary assemblages, and elements missing diagnostic markers make these distinctions very hard to gauge.

Where it was possible to attribute sex to an individual, it became apparent that the number of females present at certain other sites, may have been previously under-estimated. The excavation of Wor Barrow by Pitt Rivers in the 19th century was reported to have found the remains of three males and three more probable males within the mortuary structure (Pitt Rivers, 1894). However, re-analysis of the skeletons has revealed that Individuals, 1, 2, and 5, are more likely to be female. The sex of Individual 1 was assessed using the pelvic bones, measuring the os coxae using DSP (Murail *et al*., 2005), a tool for probabilistic sex diagnosis. The results were 0.8892% probable female, which although not enough of an emphatic indicator of sex for the authors, when compared to the results of visual determination of the *os coxae* such as the presence of a composite arch and a preauricular sulcus (Bruzek, 2002), indicates that the skeleton is likely to be that of a female (Figure 5.10).

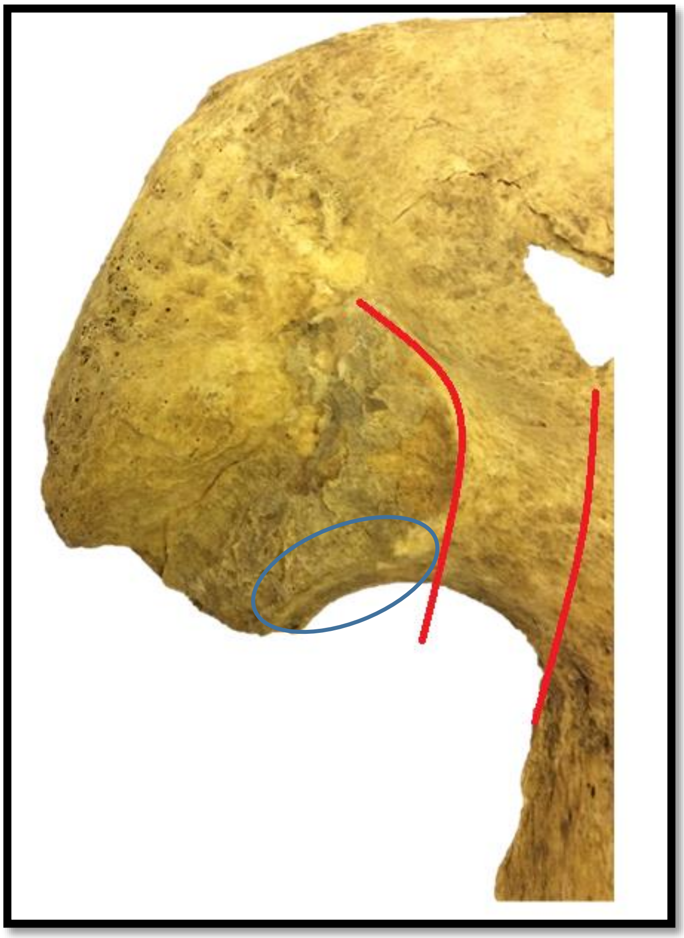


Figure 5.10: Left *os coxae* from Skeleton 1 from Wor Barrow, Dorset, with female characteristics – composite arch (red line), preauricular sulcus (blue circle).

Individual 2 was assessed as female using purely metrical methods, as no pelvic or cranial bones were retained (with the caveat that the measurements for female and male are based on modern populations, but are nevertheless useful in determining sex). The measurements of the humeral, femoral and radial heads are all well within the range for females (Stewart, 1979; Berrizbeitia, 1989). Furthermore, measurement of both petrous temporal bones, indicate the cranium is female (Wahl and Graw, 2001). Individual 5 was assessed using DSP, which gave a result of 0.9215% probable female. The os coxae also had a marked composite arch, but no pubic bones were retained. Measurements of both clavicles, humeri, and femora, together with the radial head, all suggest a likely female individual (Brothwell, 1981; Stewart, 1979; Berrizbeitia, 1989).

The excavations at Belas Knap long barrow, Gloucestershire, produced the human skeletal remains of 36 individuals. Only two individuals are mentioned in the reports as being female, five are children, and the rest are presumably male adults (Lawrence, 1866; Hemp, 1929). The re-assessment of the extant individuals from the long barrow (n = 19) concluded that eight of the adult individuals had female cranial traits, with one more possible female, compared to the rugged and decidedly male traits of the remaining five adults (with a possible two more male individuals).

5.5 Stature

The estimation of stature in skeletal remains can give insights into the health and nutritional status of individuals in the past, with ultimate adult height dependent on access to adequate nutrition, the extent of exposure to infectious agents, and genetic factors (Mays 2010: 136; Larsen 2003: 14). Stature of the adults from the assemblage were calculated using Trotters (1970) formulae, and to enable comparisons across the sites, the total length of the femur was used. Although Trotter's method used measurements from modern American cadavers, it is the most common device used in studies of human remains and can therefore be useful when comparing collections. The formula for males is 2.38 x femoral length + 61.41 ± 3.27, and for females is 2.47 x femoral length + 54.10 ± 3.72 (Trotter 1970). Only complete elements were used, and eight sites (19%, 8/42) had 54 bones that could be measured (Appendix 4).

The stature estimates ranged from the shortest female from the south-west chamber of West Kennet long barrow, who had a stature of 148cm (four feet nine inches) to the tallest females from Lanhill long barrow (EU.1.5.106) and the north-east chamber of West Kennet long barrow, who had a stature of 163cm (five feet three inches). The average (mean) stature for females was 156cm (five feet one inch). The stature estimates for males ranged from the shortest males from Lanhill long barrow

(EU.1.5.109) and Wor Barrow (Skeleton # 6) who measured 158cm (five feet two inches), to the tallest male from Handley 27, who measured 176cm (five feet and eight inches). The average (mean) stature for males was 167cm (five feet five inches).

5.6 Geographic Patterning

The number of sites from southern Britain analysed for this study is 42, and Figure 5.11 shows the number of sites in each county, the most being located in Wiltshire, and accounting for 48% (20/42) of the total.

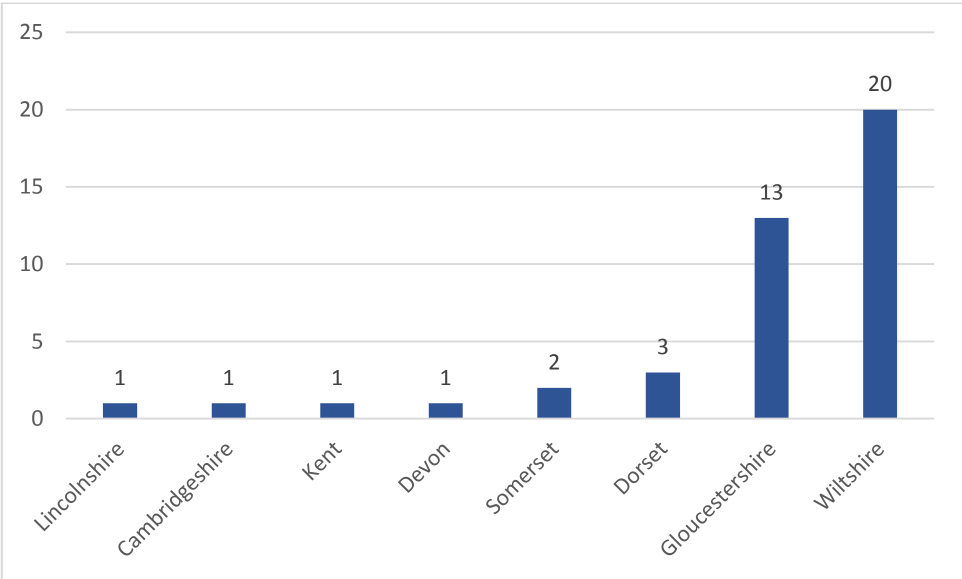


Figure 5.11: Chart showing number of sites per county.

Single burials within long barrows were located in Gloucestershire (n = 1), and two in Wiltshire. The sites with the largest assemblages totalling more than twenty individuals were also located in these two counties (Gloucestershire = 2; Wiltshire = 1).

The four Neolithic long barrows that contain evidence of scavenging by canids, which may be an indicator of excarnation (mentioned in section 5.1.3.) are all located in a small geographic area – three in Gloucestershire (Adlestrop, Hazleton North, and Bown Hill (Woodchester), and Bowls Barrow, Wiltshire. Whether this represents a local cultural practice is unclear, but evidence of this funerary rite is lacking at other long barrow sites. In fact, the only other sites that this practice has been found at are in causewayed enclosures, in locations that are further apart from the clustered long barrow sites. Etton causewayed enclosure is located in Cambridgeshire, Hambledon Hill causewayed enclosure is in Dorset, and Windmill Hill causewayed enclosure is in Wiltshire, and all of these sites report evidence of scavenging by canids (Armour-

Chelu, 1998; McKinley, 2008; and Brothwell, 1999). As these particular monuments appear later in the archaeological record, following the appearance of long barrows (Whittle *et al.,* 2011), it may be that the practice of excarnation at long barrows began as a local cultural practice, a ritual which gradually spread across southern Britain. As the population grew, this funerary rite could be witnessed by greater numbers of people at ceremonial meeting places.

5.7 Summary

The analysis of the human remains from the 42 sites revealed that only six sites (14%, 6/42) had extant skeletons, in varying states of completeness, ranging from only 4.95% to 73.8%, the other sites comprised of either just crania and mandibles or disarticulated bones. All of the bones from the sites were very fragmented, except for four sites (Bratton Camp, Figheldean Down, Gatcombe Lodge, and Tilshead Old Ditch) which consisted of only crania and mandibles.

Taphonomic alteration varied at the different sites, with evidence of erosion, weathering, root action and fractures. New evidence of Neolithic funerary behaviour was revealed at Hazleton North long barrow and Bown Hill long barrow, in the form of scavenging by canids, probably during the ritual of excarnation. Sixty three bones had evidence of gnawing by mammals, 57 of which were by large animals. Patterns of damage on the diaphyses and femoral heads were consistent with those inflicted by canids. This evidence is significant, as it adds weight to the archaeological record that this rite was practiced at long barrow sites, evidence of which has only been found at Adlestrop, Bowl's Barrow, and Parc Le Breos so far. Other funerary behaviour exhibited at sites consisted in the majority of cases as multiple burials, with two examples of primary burials witnessed at Hazleton North long barrow and Lanhill long barrow. Cremation was the method of disposal of the human remains at Chestnuts long barrow, but was also carried out alongside inhumation at seven other sites. The weight of the cremation deposit at sites was far too light to be evidence of the complete cremated corpse, and at Hazleton North, of three individuals. These burials may therefore represent a token deposit, where the inclusion of all the burnt material was not deemed necessary.

Analysis revealed that the MNI varied at sites from only one individual, to 42 at West Kennet long barrow. A total of 305 individuals for all sites was calculated, comprised of 223 adults (73% of the assemblage, 223/305), 16 juveniles (5%, 16/305), and 66 children (22%, 66/305). The adults were split into age categories, with 69 young adults, 54 middle adults, 23 old adults, and 77 unaged adults. The assemblage was determined for sex, and found that 28% (63/223) were male, 15% probable males (24/223), females 26% (57/223), and 5% were probable females, leaving 26% (58/223) unsexed.

Geographic patterning of the sites studied revealed that 48% (20/42) were located in Wiltshire. In addition, it was found that the four long barrows with evidence of excarnation having been practiced in the vicinity are all located in a small geographic area, perhaps indicating a local cultural practice that was later adopted at larger and more public causewayed enclosures.

Estimations of stature ranged from 148cm to 163cm for females, with a mean of 156cm. The male individuals ranged from 158cm to 176cm, with a mean of 167cm. Variation of stature within the population is influenced by access to adequate nutrition, exposure to disease, and genetic factors.

Chapter 6: Metabolic Bone Disease and Non-Specific Indicators of Stress

6.1 Metabolic Bone Disease

Metabolic disease was a term devised by Albright and Riefenstein in 1948 to describe conditions that cause disruption to normal bone formation, remodelling or mineralization (cited in Brickley and Ives 2008: 2). In order to function efficiently, bone cells require a constant supply of nutrients and minerals to maintain strength and encourage growth, and failure to maintain this delicate balance leads to dietary deficiencies, which disrupts the metabolic pathways, affecting skeletal remodelling and development (Koztowski and Witas 2012: 402). In consequence, metabolic diseases such as scurvy, rickets, osteomalacia, and osteoporosis, leave indelible traces on the skeleton, highlighting the health of an individual but also allowing inferences on subsistence strategies, living and environmental conditions, and cultural and social practices to be made (Brickley and Ives 2008: 7).

6.1.1: Scurvy

Scurvy is caused by the lack of vitamin C, or ascorbic acid, in the diet, a nutrient that is found in fresh fruit (especially citrus fruits) and uncooked vegetables, and to a lesser extent in marine fish, meat and milk (Brickley and Ives 2009: 41; Fain 2005: 124). Vitamin C is soluble in water, and cannot therefore, be adequately stored in the body, necessitating a regular supply to avoid scurvy (Waldron 2009: 131), and it is essential to fight infection, to aid in the absorption of iron and to allow the normal formation of all the bodily tissues, especially collagen (Koztowski and Witas 2012: 403). Lack of vitamin C will therefore impair collagen synthesis, resulting in defective osteoid formation, with consequent implications for skeletal growth in affected children, and compromised cell walls of the blood vessels, leading to haemorrhage (Aufderheide and Rodríguez-Martin 2011: 310).

Recognising scurvy in adult human skeletal remains is quite challenging, as the scorbutic porosity tends to be fairly diffuse, and the bleeding, swollen gums that are often associated with the disease may be recognised in archaeological bone through tooth loss and porous alveolar bone, but these features may also be due to other causes (Mays 2008a: 223: Ortner 2003: 387). Instead, the presence of several ossified haematomas on the sub-periosteal surfaces of the long bones may be more indicative of the presence of scurvy in adult skeletons (Aufderheide and Rodríguez-Martin 2011:

311). Indeed, Maat (2004) describes the findings from a burial site on the Spitsbergen Archipelago, where 50 Dutch Whalers had been interred in the 17^{th} and 18^{th} centuries. Thirty nine of the skeletons were considered to have suffered from scurvy, based on dark stains found on the long bones and on the tooth roots, which, following scientific testing, were found to be the remains of haematomas that had fortunately been preserved in the cold environment (Maat 2004: 79).

Despite affecting individuals of all ages, scurvy in childhood is more prevalent, perhaps because it is easier to identify but rarely occurs before four months of age, as vitamin C is passed from the mother to the baby via the placenta while *in utero*. In fact, the maximum prevalence is seen in infants between the ages of eight and ten months (Stuart-Macadam 1989: 219). Therefore, even if little or none of the nutrient is available following birth, it will take a few months for recognisable signs of the disease to appear, unless the mother herself was suffering from scurvy (Fain 2005: 126; Ortner 2003: 384). The speed at which vitamin C deficiency affects the body has been detailed by Fain (2005): serum ascorbic acid levels are undetectable just 41 days following the cessation of vitamin C intake, cell depletion occurs after 121 days, and the initial appearance of lesions on the skin appear after 132 days. In addition, dental abnormalities may occur after six months (Fain 2005: 125).

Recognition and reporting of scurvy in juvenile skeletal material was rarely seen before Ortner and others questioned the paucity of evidence for the disease in sub-adults, concluding that the condition was either misdiagnosed, or not recognised in the past (Ortner and Ericksen, 1997; Ortner *et al*., 1999; Ortner *et al*., 2001). When haemorrhage caused by lack of vitamin C occurs adjacent to the bone, the periosteum is stimulated to produce new bone. In addition, extravasated blood can encourage the increase of blood vessels at the site of injury, which penetrate the underlying hard bone, causing the characteristic porosity that can be seen on human skeletal remains (Ortner and Ericksen 1997: 213). The porous lesions can be seen on the ectocranial vault, the orbital roof, the greater wing of the sphenoid, the posterior surface of the maxilla, and on the hard palate (Ortner 2003: 388-9). Additionally, lesions are commonly found on the ribs and long bones, accompanied by flaring of the distal ends and fractures, with the scapulae and pelvic bones sometimes being affected too (Ortner 2003: 386-7).

There have been no definite cases of scurvy reported in the literature for the Neolithic period in Britain or in Robert and Cox's (2003) review of health in the prehistoric period. However, Smith and Brickley's (2009) synthesis on the human remains from Cotswold Severn monuments mentions one possible case from West Tump long barrow (Cranham), where there is porosity and new bone formation in the orbital roof of an infant. The authors suggest that the cause of this phenomenon is due to a pathological condition, such as scurvy, or possibly trauma, that has resulted in bleeding within the orbit (Smith and Brickley 2009: 120). Additionally, Lawrence (2012: 532) discusses some possible cases from Isbister chambered cairn, on South Ronaldsay, Orkney.

The analysis of the human remains from 42 Neolithic monuments for the current study revealed that there may be evidence of this disease at three sites: Hazleton North; Belas Knap; and Fromefield. Two infants, one from Belas Knap long barrow (individual 13f), and the other from Hazleton North long barrow (# (5378), both have porosity and new bone formation on the orbital roof - in the case of the infant from Belas Knap, it is bilateral, although only one orbit is pictured (Figure 6.1C).

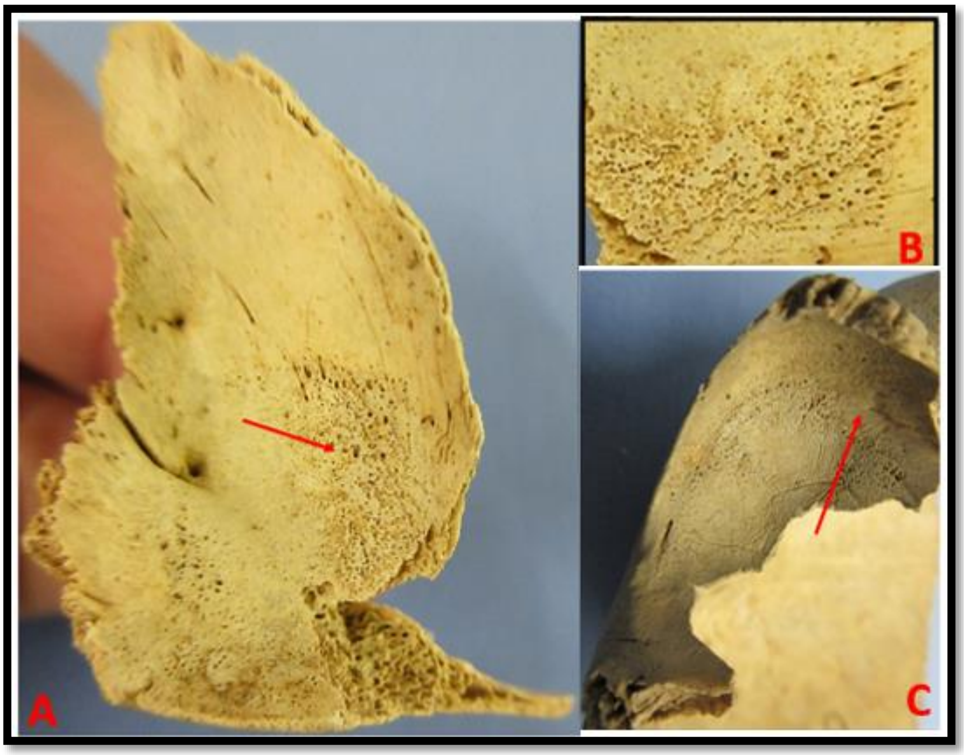


Figure 6.1: A & B - Frontal bone from infant at Hazleton North long barrow (#5378). C – Frontal bone from Belas Knap long barrow (individual 13f), with porosity and new bone formation in the orbit (red arrows).

Although haemorrhaging into the orbit is a sign of scurvy, this evidence on its own is not sufficient to make such a diagnosis, and as Smith and Brickley (2009: 120) point out, analysing disarticulated and fragmentary assemblages is very problematic, as a relatively complete skeleton is usually needed to make a balanced and considered diagnosis.

However, three more individuals from Hazleton North long barrow exhibit lesions of greater severity, possibly indicative of scurvy. Individual 11062, a child aged between five and six years (based on dental eruption), has fine porosity concentrated on the frontal bone in the glabella region, a porous hard palate, and porosity and new bone formation in the orbit (Figure 6.2).

Figure 6.2: A - Child (# 11062) from Hazleton North long barrow, with porous hard palate and B - porosity and new bone formation in the orbit.

The second individual (# 12527), a child of about eight years old (based on dental eruption) and also from Hazleton North long barrow, is reported to have suffered from cribra orbitalia (Rogers 1990: 196), but this condition usually only affects the roof of the orbit (Aufderheide and Rodríguez-Martin 2011: 349). The child does have porous bone in the orbits, but it appears more depositional on the medial portion of the orbit (Figure 6.3, circled in red), rather than caused by the thinning of the orbital roof, which is characteristic of cribra orbitalia (Walker *et al.* 2009: 11). However, as noted by Ortner *et al.* (1999: 329), both scurvy and cribra orbitalia can be present in the same individual. In addition, the child has porosity on the superior portion of the squamous temporal (left side) and the left greater wing of the sphenoid (Figure 6.4), locations on the cranium which have been identified to be indicative of scurvy, due to the vascular supply to the region for the temporalis muscle, which is concerned with chewing (Ortner and Ericksen 1997: 215).

Figure 6.3: Child (# 12527) from Hazleton North long barrow, with bilateral porosity and new bone in the orbits (circled).

Figure 6.4: Porosity on the left greater wing of the sphenoid of the eight year old child (# 12527) from Hazleton North long barrow.

The last individual from Hazleton North long barrow (# 6261) with possible scurvy is a nine month old infant, represented only by a maxilla and mandible. The orbital surface of the maxilla is extremely porous, as is the posterior and lateral side of the maxilla. In addition, the hard palate is very porous, with marked porosity in the sockets. The mandible is also very porous on the internal surface of the ramus, with porosity and plaques of new bone surrounding the sockets (Figure 6.5). It is extremely unfortunate that the remaining portions of the cranium and skeleton are missing, as the lost elements would be able to contribute to a more reliable diagnosis, but the remaining maxilla and mandible certainly indicate that this individual suffered a pathological condition, possibly scurvy.

Figure 6.5: Maxilla and mandible of a nine month old infant (#6261) from Hazleton North long barrow, showing porosity on: A - orbital surface of the maxilla; B - posterior and lateral side of the maxilla; C - Internal ramus and surrounding the tooth sockets; and D - the hard palate of the maxilla.

Finally, a neonate (infant #1, according to Keepax 1973: 26) from Fromefield long barrow may have suffered from scurvy, which was overlooked in the original bone report. The fact that the child was new-born indicates that the mother must have been severely malnourished and was not able to pass on the benefits of a well-balanced diet to her child (Brickley and Ives 2008: 45). The adoption of agriculture in the

Neolithic period may not have been that beneficial to the consumption of a healthy, well-balanced diet, as fresh ingredients would not have been utilised as they had in the past. Hunter-gatherers select fresh foodstuffs on a daily basis, typically utilising between 200 and 300 different plant foods, thereby ensuring that they have a well-balanced diet (Cordain 1999: 23). Conversely, the transition to agriculture limited the range of plant foods utilised, reducing the quantity to only between 20 and 50 species, with a greater reliance on cereals and stored goods, which contain little or no vitamin C (Cordain 1999: 23). According to Mays (2014: 60) the seasonal fluctuations in availability of fresh fruit and vegetables is not a credible explanation for the presence of scurvy in past populations, and is more likely to be explained by cultural, rather than environmental factors.

Infant #1 from Fromefield long barrow is better represented than the individuals from the above sites but still only comprises of: both femora; both tibiae; both humeri; the left radius and ulna; left ilium; two ribs; a partial maxilla; and some cranial fragments. All of these elements, except the ilium and ulna, exhibit considerable porosity (Figure 6.6), without any sign of new bone formation (except on the hard palate of the maxilla), indicating that the infant may not have ingested enough vitamin C following birth, but suffered multiple events of periosteal haemorrhaging.

Figure 6.6: Infant #1 from Fromefield long barrow showing: A - porosity on the metaphysis and diaphysis of the femur; B - porosity on the posterior and lateral side of the maxilla; C - endocranial lesions affecting the parietal bone; D - extensive porosity on the petrous temporal; E - porosity on the hard palate, with additional new bone.

In summary, six individuals from the current study (Table 6.1) are deemed to have suffered from scurvy, giving a crude prevalence rate of 2% (6/305). Whilst this rate is low, it is significant: the reporting of cases of scurvy in British Neolithic assemblages is very rare. In fact, only two sites have reported evidence of the disease: Smith and Brickley (2009: 120) discuss a possible case of the disease from West Tump long barrow, and Lawrence (2012: 532) discusses some possible cases from Isbister chambered cairn, on South Ronaldsay, Orkney.

Table 6.1: Summary of cases of scurvy from this study

Site	Bone Affected	Porosity	New Bone Formation	Lesions
Belas Knap # 13f	Cranium - Frontal	✓	✓	
Fromefield # 1	Femur L & R	✓		
"	Tibia L & R	✓		
"	Humerus L & R	✓		
"	Radius L	✓		
"	Ribs x 2	✓		
"	Cranium - Maxilla	✓	✓	
"	Cranium - Parietal			Endocranial
"	Cranium - Temporal	✓		
Hazleton N # 5378	Cranium - Frontal	✓	✓	
Hazleton N # 11062	Cranium - Frontal	✓	✓	
"	Cranium - Maxilla	✓		
Hazleton N # 12527	Cranium - Frontal	✓	✓	
"	Cranium - Temporal	✓		
"	Cranium - Sphenoid	✓		
Hazleton N # 6261	Cranium - maxilla	✓		
"	Mandible	✓	✓	

6.1.2 Rickets and Osteomalacia

Rickets is a childhood disease caused by lack of vitamin D, which is characterised by skeletal deformities, retarded growth, porous lesions and woven bone deposition (Kozlowski and Witas 2012: 405). In contrast to vitamin C, vitamin D can be synthesised by the body by absorbing ultraviolet light through the skin, a process so efficient, that 90% of the body's requirements are obtained this way (Mays *et al*. 2006:

362). Vitamin D can be obtained naturally in small amounts from some foods such as eggs, liver and oily fish, but is artificially boosted today in foods such as butter, margarine, yogurt, and cheese (Holick 2006: 2065).

Vitamin D is vital for the metabolism of calcium and phosphorus, and without it, the maintenance of existing bone tissue cannot occur, whilst also hindering the mineralisation of new formed bone (Mays *et al.* 2006: 362). In consequence, any bone that is formed will be very soft, and may bend if the child is weight bearing, for instance, in the upper limb if the infant begins crawling, or the lower limb and pelvis, during walking (Waldron 2009: 127). Furthermore, a deficiency of mineralised bone deposited at the end of the diaphysis during growth results in porosity and a coarsening of the bone underlying the growth plate (Mays 2008a: 216). In addition, the ends of the long bones widen and flare in a characteristic trumpet shape, together with a cupping of the metaphysis (Ortner 2003: 394). Flaring and enlargement at the costo-chondral junctions causes nodular swellings, referred to as the rachitic rosary (Waldron 2009: 129). The cranium may be affected too, with persistent fontanelles, flattening of the occipital and parietals (craniotabes) and delayed tooth eruption (Ortner 2003: 394).

If treated, either with more exposure to sunlight and/or vitamin supplements, a child may recover from the deformities caused by rickets, whereby the porous bone is infilled and the cortical defects obliterated (Mays 2008a: 216). However, left untreated, the deformities and bowed limbs will remain into adult life (Mays 2008a; 218), and which in the case of a deformed pelvis, could have catastrophic consequences for women during childbirth (Brickley and Ives 2008: 85).

Rickets rarely appears before the child has reached four months of age, as vitamin D is passed from the mother to the foetus across the placenta, where it is stored in the liver (Ortner 2003: 393). However, if the mother is suffering from hypovitaminosis D, the baby will be born with rickets (Maiyegun *et al.* 2002: 194). The disease is most commonly observed between six months and two years of age, when the stores of vitamin D passed on by the mother begin to deplete, but is rarely seen after four years of age (Ortner 2003: 393; Lewis 2007: 120).

Archaeological evidence of rickets in Britain does not appear until the 10th century, and is scant from the Medieval period, but appears in greater numbers during the 16th to 19th centuries, when urban pollution, which would have blocked out the sunlight, was reaching its peak (Mays 2008a: 220). Thirty five individuals (20 children and 15 adults) were reported to have had rachitic changes to their bones when they were examined from the 18th/19th century graveyard at Spitalfield Hospital in London (Molleson and Cox 1993: 153). Similarly, a cemetery from the same period, St Martin's in the Bull Ring, Birmingham, was excavated and was found to contain 7.5% of individuals suffering from rickets (Brickley *et al*. 2006: 132).

The current study found no evidence of rickets in the bones analysed, except for one possible case excavated from West Kennet long barrow, Wiltshire, giving a CPR of 0.3% (1/305). The right femur of a child aged about four and half years, was recovered from disarticulated human remains in the south-east chamber. The distal femur has disordered swelling and flaring of the metaphysis and angulation of the growth plate (Figure 6.7), both signs of rickets (Brickley and Ives 2008: 91). In addition, the diaphyseal bone that underlies the epiphyseal growth plates is roughened, and has macroporosity, together with cupping of the distal end of the diaphysis (Mays 2008a: 216) (Figure 6.8).

Figure 6.7: A **- Right femur of a child of 4.5 years from West Kennet long barrow, with swelling of the distal end and angulation of the growth plate. B - Photograph of replica of similar age for comparison.**

It can be assumed that the rest of the skeleton was possibly distributed around the rest of the chambers in the tomb, however, examination of all the extant bones from the assemblage did not reveal any further examples. Nevertheless, the femur does feature characteristics of the disease, more usually associated with the poor inhabitants of cities during the industrial revolution of the nineteenth century, where access to daylight was restricted by smog, and the disease reached epidemic proportions (Mays 2008a: 219). In considering why a child from the Neolithic could be suffering from rickets, it can only be assumed that the individual had not been able to venture outside for an extensive period, and was confined within the dwelling (either through disability or illness), and was unable to absorb ultraviolet light from the sun's rays. The fact that this is an isolated case, would confirm that environmental issues were not to blame.

Figure 6.8: Femur of a child from West Kennet long barrow with porosity and roughened bone underlying the growth plate, together with cupping of the distal end.

6.1.3. Osteoporosis

Osteoporosis is a metabolic disease that affects the elderly, altering the important balance between bone resorption and bone formation (Grynpas 2003: 33). When young, and up until the fourth decade, bone is constantly resorbed but formed at a higher rate, but in later life, the balanced becomes skewed, with continued resorption but slower formation (Brickley and Ives 2008: 215). As a result, bone strength is reduced and fractures become more likely (Christadoulou and Cooper 2003: 133). Both cortical and trabecular bone are affected in osteoporosis, and dry specimens may look fairly normal but have greatly reduced weight compared to other individuals from the same site (Ortner 2003: 413). However, diagenesis, the chemical, physical, and biological changes undergone by a bone through time, may account for differences in the microstructure and chemical composition of the bones (Cho and Stout 2003: 211; White *et al*. 2012: 581), and therefore the lightness of different bones in the skeleton is not a reliable indicator for the disease.

A figure of between 20% and 30% for cancellous bone and between 5% and 10% for cortical bone, has been suggested as the extent of bone loss experienced by individuals suffering from osteoporosis (Riggs *et al*. 1998: 763). Consequently, the trabecular bone becomes thin, resulting in a loss of bone strength, giving rise to many fractures seen at sites of the most abundant trabecular bone – the femoral neck, distal radial metaphysis (Colles' fracture) and the vertebral bodies (Mays 2008a: 227). The cortical bone becomes eroded, with porosity gradually encroaching into the periosteum, and resorption of the bone increasing the diameter of the medullary cavity, and a consequent reduction in cortical thickness (Aufderheide and Rodríguez-Martin 2011: 315).

Osteoporosis may be divided into two main types – primary and secondary osteoporosis, with a further subdivision of the primary category, into Type I and Type II (Waldron 2009: 119). Primary osteoporosis is caused by age-related factors and the subsequent drop in sex hormones (Ortner 2003: 411). Type I mainly affects women who are post-menopausal and are typically between the ages of 55 and 75, but does affect some men too (sex ratio F: M of 6:1) (Riggs and Melton 1986: 1986). Bone loss is most apparent in the trabecular areas; and the type of fractures commonly associated with this type are of the wrist (Colles' fracture), and crush injuries to the vertebrae (Riggs and Melton 1986: 1681). Type II osteoporosis is termed "senile" osteoporosis and affects both men and women, in a ratio of 2:1 (F: M) and occurs in the elderly over 70 years of age; bone loss is most evident in the trabecular and cortical areas, with fractures occurring in the hip and the vertebral bodies (Riggs and Melton 1986: 1681-2; Brickley and Agarwal 2003: 158).

Secondary osteoporosis is caused by three main factors: disuse atrophy as the result of injury or pathological change in the affected limb or the vertebral column, which limits mobility; as a specific feature of a disease; or dietary deficiencies which disturb the metabolism (Brickley and Ives 2008: 185).

Cases of osteoporosis from the Neolithic period are scant, in fact, only one is mentioned by Roberts and Cox (2003) in their synthesis on health and disease in prehistory. Here, they cite Cave's (1938) report of the inhumations from Lanhill long barrow, which states that the elderly woman buried within the tomb has osteoporosis, based on changes within her vertebral column (Cave 1938: 134-5). However, there is no mention of osteoporosis regarding a mature adult from the monument (EU.1.5.104), who is estimated to be between 50 and 60 years of age at death. The skeleton of this individual is only 34.9% complete (see chapter 5), but displays several pathological features that are characteristic of the disease. All of the extant long bones, the tali and calcanei, and the existing vertebrae were noted to be extremely lightweight and porous. In addition, the left and right femur and the right tibia were damaged post mortem, exposing the distal ends, and on inspection, these elements exhibited extreme cortical thinning (Figure 6.9A). Furthermore, four of the cervical vertebrae have suffered collapse to the anterior bodies (Figure 6.9 B and D).

Whilst it is acknowledged that fractures to vertebrae caused by osteoporosis more frequently affects the thoracic and lumbar regions (Brickley and Ives 2008: 180), it has been noted by Court Brown and Caesar (2006: 696) that the disease should also be recognised in the cervical spine. Lastly, the individual had a healing fracture on the body of a rib (Figure 6.9C). Even though he appears to be younger than those usually affected by the disorder (70 years plus), the suite of indicators of osteoporosis exhibited (cortical thinning on the left and right femora and the right tibia, four wedge-shaped cervical vertebrae, caused by collapse of the anterior bodies, and a healing fracture of a rib), suggest that this individual may possibly have suffered from Type II osteoporosis.

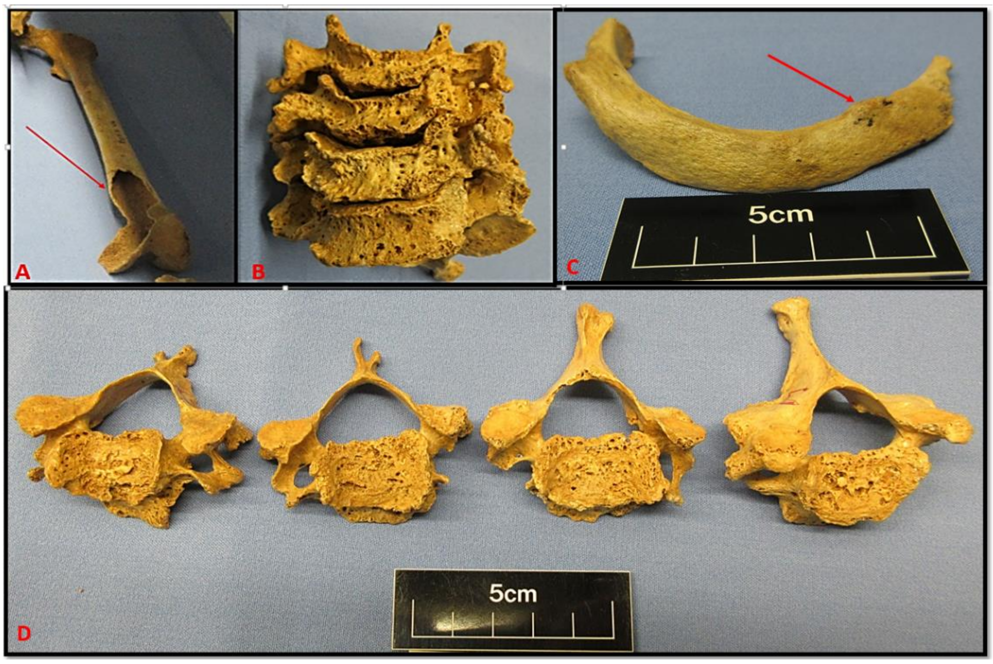


Figure 6.9: Mature male adult from Lanhill long barrow (EU.1.5.104), displaying signs of osteoporosis: A - Distal left femur with cortical thinning; B - cervical vertebrae with wedge-shaped bodies; and C - body of a rib with healing fracture. D – Detail of wedge-shaped bodies of the affected cervical vertebrae

A probable female individual from West Kennet long barrow is represented by long bones, cranial fragments and a mandible, and her age is estimated as at least 50 years of age at death. None of these elements give any indication of disease, except for a healed Colles' fracture to her left radius (Figure 6.10), a traumatic injury often seen in adults suffering from Type I, primary osteoporosis. However, with well-healed fractures, it is difficult to identify when the injury occurred (Brickley and Ives 2008: 176). This study has therefore identified two possible cases of osteoporosis, giving a CPR of 0.6% (2/305).

Figure 6.10: Mature probable female from West Kennet long barrow with healed Colles' fracture.

When most of the assemblages studied for this project are in a disarticulated state, it is very difficult to assign particular bones to individuals, and then to make a differential diagnosis on any pathology found. However, three sites out of the 42 studied contained collapsed vertebrae. Broadsands long barrow contained one lumbar vertebra that had suffered collapse to the vertebral body in the form of a wedge-shaped deformity; Hazleton North long barrow had two thoracic vertebrae, and four contiguous lumbar vertebrae that were collapsed in the same manner; and West Kennet long barrow contained three thoracic and one lumber vertebra also exhibiting this type of fracture. Of course, the affected vertebrae may have resulted from some sort of trauma, and on their own, are not indicative of osteoporosis. Table 6.2 summarises the metabolic conditions detailed in the study.

Table 6.2: Summary of the metabolic diseases found during the study.

Site	Disease	Bone Affected	Indicators	Age	Sex
Belas Knap # 13F	Scurvy	Frontal	Porosity, new bone	Infant	?
Hazleton North # 5378	Scurvy	Frontal	Porosity, new bone	Infant	?
Hazleton N # 11062	Scurvy	Frontal	Porosity, new bone	5-6 years	?
"	"	Maxilla	Porosity	"	?
Hazleton N # 12527	Scurvy	Frontal	Porosity, new bone	8 years	?
"	"	Sphenoid	Porosity	"	?
"	"	Temporal	Porosity	"	?
Hazleton N # 6261	Scurvy	Maxilla	Porosity	9 months	?
"	"	Mandible	Porosity	"	?
Fromefield # 1	Scurvy	Femora	Porosity	Neonate	?
"	"	Tibiae	Porosity	"	?
"	"	Humeri	Porosity	"	?
"	"	L Radius	Porosity	"	?
"	"	Ribs x2	Porosity	"	?
"	"	Parietal	Porosity	"	?
"	"	Temporal	Porosity	"	?
"	"	Maxilla	Porosity, new bone	"	?
West Kennet	Rickets	Femur	Swelling/flaring metaphysis. Macroporosity & cupping distal end plate	4.5 years	?
Lanhill # 104	Osteoporosis	Femur	Cortical thinning	50-60 yrs	M
"	"	Rib	Fractures	"	M
"	"	Vertebrae	Collapsed bodies	"	M
West Kennet	Osteoporosis	Radius	Colles' fracture	50+	F?

6.2. Non-Specific Indicators of Stress

Non-specific indicators of stress may be seen on skeletal human remains as the physical manifestation of the body's response and adaptation to stressors experienced during the formative years, when growth is at its most vigorous stage (Ribot and Roberts 1996: 67). "Stress", a term coined by Selye in 1957, discussed the ability of an individual to respond to the demands of the surrounding environment, focussing on their physiological reaction, in later years defined as the "non-specific response of the body to any demand" (Selye 1976: 53). The ways in which physiological stress is expressed in the human body are discussed by Goodman *et al.* (1988). The clearest manifestation of stress suffered at a population level, can be seen when observing mortality profiles, but on an individual basis, adult stature, evidence of retardation, decreased sexual dimorphism, changes in the morphology of the vertebral canal and cranial base height, dental asymmetry, crowding and enamel defects, traumatic lesions and periosteal infections, premature bone loss, cribra orbitalia, and porotic hyperostosis, are all good indicators of non-specific stress (Goodman *et al*. 1988: 179).

Not all individuals within a group may suffer from the effects of stress, because factors such as environmental constraints, genetic susceptibility, higher levels of immunity, and cultural systems (such as status within the group), may affect the outcome (Schell 1997: 68). Furthermore, establishing which individuals suffered from stress may be problematic. The osteological paradox states that an individual who exhibits no signs of stress had been healthy in life, but it may also be the case that this individual was in a constant state of stress, and never recovered – "the presence of an inactive lesion (i.e. healed) indicates *survival* of a disease process earlier in life and thus may signify an individual whose frailty is *low* compared with those who died at earlier ages" (Wood *et al*. 1992: 352). However, when other forms of evidence are taken into account, such as subsistence and settlement, the archaeological context (cultural and environmental), and population structure, it may be possible to infer levels of health and stress in past populations (Larson 2003: 337).

One of the most common forms of non-specific indicators of stress is enamel hypoplasia of the dentition, which is discussed in detail in Chapter 9, Dental Disease.

6.2.1. Cribra Orbitalia

Cribra orbitalia, or diploïc hyperplasia, is a condition that is mostly witnessed in children, but where it is evident in adult human skeletal remains, it is thought to be a relic of disease experienced in childhood (Stuart – Macadam 1985: 393; Walker *et al.* 2009: 111). The pitting, or lesions, that are present on the orbital roof, are thought to be produced by expansion of the diploë, causing the ectocranial layer of the cranium to thin, thus revealing the spongy layer beneath (Mays 2010: 209; Waldron 2009: 137). For many years, the aetiology of cribra orbitalia was thought to be iron-deficiency anaemia, often a symptom of poor diet, iron malabsorption, or severe iron loss due to intestinal parasites or disease (Stuart-Macadam 1992: 40; Wright and Chew 1998: 925). However, the iron-loss hypothesis as the cause of cribra orbitalia has been much debated recently, and it has been stated that iron-loss does not account for the lesions found in individuals suffering from this condition (Walker *et al*. 2009: 112). Moreover, individuals who suffer from iron-deficiency anaemia do not increase red-blood cell production in bone marrow, but rather reduce it, making the explanation that expansion of the diploïc layer within the cranium causes the lesions invalid (Walker *et al*. 2009:119). The aetiology of cribra orbitalia is therefore considered by Walker and colleagues (2009) to be due to megaloblastic anaemia, caused by the lack of animal protein in the diet, which is passed on by nursing mothers with depleted reserves of vitamin B12 and vitamin B9, and by diarrheal infections caused by lack of sanitary living conditions during the weaning phase (Walker *et al*. 2009: 119). In addition, the lesions exhibited in cribra orbitalia may be a result of a co-deficiency of vitamin C, which cause sub periosteal bleeding in the orbital roof (Walker *et al*. 2009: 119). However, the debate on the relationship of cribra orbitalia and iron-deficiency anaemia has not abated, with Mays (2012: 293) contending that the views expressed by Walker *et al*. (2009) are not fully supported by the biomedical literature. In addition, clinical studies, although sparse, show that hyperplasia of the diploïc layer can occur in patients suffering from iron-deficiency anaemia, together with increased red blood production (Mays 2012: 293).

Roberts and Cox (2003: 67) report a CPR of 13.8% and a TPR of 26.9% for cases of cribra orbitalia from three Neolithic sites. The current study found that 12 out of the 42 sites analysed contained individuals who suffered from cribra orbitalia (Table 6.3). Twenty-one individuals were affected out of a total of 305, giving a CPR of 7%, and

38 out of the 261 orbits examined were affected, giving a TPR of 14.6%. There was no significant difference in the number of males and females affected by cribra orbitalia: six males and five probable males, six females and two probable females, and two juveniles were affected. Twelve male orbits and eleven female orbits were affected and when the TPR is calculated for sex, the rate for females is 15% (11/73 orbits) and 13.9% for males (12/86 orbits).

The current study reports a lower CPR than that given by Roberts and Cox (2003: 67) and this may be partly due to the fact that of the six individuals reported as suffering from cribra orbitalia at Hazleton North by Rogers (1990: 196), only two were considered by the present author to have this condition (Figure 6.11) – the other four were probably suffering from scurvy (see section 6.1.2 above).

Figure 6.11: Male individual from Hazleton North long barrow, with evidence of cribra orbitalia.

Table 6.3: Cribra orbitalia at sites and number of individuals affected.

SITE	MNI	# Affected	Male	Female	Juvenile	CPR%	# Orbits	# Affected	TPR%
Avening	3	0	0	0	0	0	0	0	0
Avenis (Smart's Farm)	5	0	0	0	0	0	0	0	0
Belas Knap	19	3	1	1	1	15.8%	33	6	18.2%
Bown Hill (Woodchester)	3	0	0	0	0	0	2	0	0
Bratton Camp	1	0	0	0	0	0	2	0	0
Broadsands	6	0	0	0	0	0	4	0	0
Chestnuts	7	0	0	0	0	0	1	0	0
Figheldean Down (31)	1	0	0	0	0	0	2	0	0
Fittleton Down (5)	1	0	0	0	0	0	0	0	0

Fromefield	18	0	0	0	0	0	3	0	0
Fyfield (Giants Grave)	2	0	0	0	0	0	2	0	0
Gatcombe Lodge	1	0	0	0	0	0	2	0	0
Giant's Hills (Skendleby I)	6	0	0	0	0	0	3	0	0
Haddenham	5	0	0	0	0	0	2	0	0
Handley 26	1	0	0	0	0	0	1	0	0
Handley 27	1	0	0	0	0	0	2	0	0
Hazleton North	41	2	1	1?	0	4.9%	22	4	18%
Hetty Pegler's Tump (Uley)	5	0	0	0	0	0	4	0	0
Horton Down (Bishops Cannings 91)	1	0	0	0	0	0	0	0	0
Imber (Bowls Barrow)	5	2	0	1 1?	0	40%	9	4	44.4%
Jackbarrow	3	0	0	0	0	0	4	0	0
Kings Playdown (Heddington 3)	1	0	0	0	0	0	2	0	0
Lamborough Banks (Ablington)	1	0	0	0	0	0	0	0	0
Lanhill	8	1	1	0	0	12.5%	9	2	22%
Littleton Drew (Lugbury)	12	1	1?	0	0	8.3%	17	1	5.9%
Luckington (Giants Cave)	11	0	0	0	0	0	2	0	0
Millbarrow	8	0	0	0	0	0	1	0	0
Netheravon Down (6)	2	0	0	0	0	0	2	0	0
Norton Bavant	12	3	0	2	1	25%	22	4	18.2%
Nympsfield	9	2	1?	1	0	33.3%	8	4	62.5&
Oldbury Hill	3	0	0	0	0	0	6	0	0
Randwick	3	1	1	0	0	33%	4	2	50%
Rodmarton	12	1	0	1	0	8.3%	7	2	28.5%
Stonehenge (Amesbury 14)	3	1	1	0	0	33%	3	2	66.7%
Stoney Littleton	2	0	0	0	0	0	0	0	0
Tilshead East (7)	8	2	2?	0	0	25%	6	3	50%
Tilshead Lodge	2	0	0	0	0	0	4	0	0
Tilshead Old Ditch	1	0	0	0	0	0	2	0	0
West Tump (Cranham)	1	0	0	0	0	0	0	0	0
Winterbourne Monkton	22	0	0	0	0	0	32	0	0
Wor Barrow	7	0	0	0	0	0	10	0	0
West Kennet	42	2	1	0	0	4.8%	26	4	15.4%
TOTALS	305	21	6 5?	6 2?	2	7%	261	38	14.6%

6.2.2. Porotic Hyperostosis

Porotic hyperostosis is characterised by bilateral cranial lesions of the ectocranium, usually located on the parietals and the frontal bones, but rarely on the occipital, and in its most severe form, the affected cranial bones become thickened and the ectocranial layer completely resorbed (Aufderheide and Rodríguez-Martin 2011: 348). Porotic hyperostosis is seen in its most severe form in very young children, but where the ectocranial layer has been affected less severely, or in older individuals who may be recovering from the condition, the lesions are characterised by discrete lesions that are only the size of a pin-head (Aufderheide and Rodríguez-Martin 2011: 349).

As with cribra orbitalia, the etiology of porotic hyperostosis was considered to be iron-deficiency anaemia, but the work of Walker *et al*. (2009) considers that this condition is due to megaloblastic anaemia, which is passed on by nursing mothers with depleted reserves of vitamin B12, caused by lack of animal protein and vitamin-rich plant foods in the diet, together with weaning foods that are deficient in nutrients (Walker *et al*. 2009: 113).

The current study found that 15 of the 42 sites studied had individuals who suffered from porotic hyperostosis. Sixty-one individuals had this condition, giving a CPR of 20% (61/305). However, none of them were affected severely (Figure 6.12). Fifteen males and 12 probable males, 16 females and five possible females, nine unsexed individuals and four children were affected (Table 6.4).

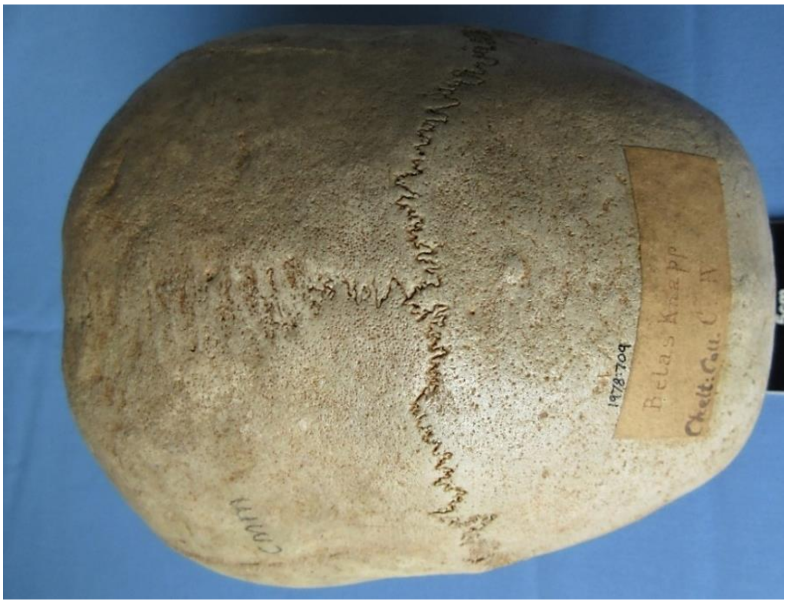


Figure 6.12. Adult male from Belas Knap (# civ) suffering from porotic hyperostosis.

Table 6.4. Individuals suffering from porotic hyperostosis at the sites.

SITE	MNI	# Affected	Frontal	Parietals	Occipital	CPR%
Avening	**3**	**0**	**0**	**0**	**0**	**0**
Avenis (Smart's Farm)	**5**	**0**	**0**	**0**	**0**	**0**
Belas Knap	**19**	**10**	**1**	**10**	**0**	**52.7%**
Bown Hill (Woodchester)	**3**	**0**	**0**	**0**	**0**	**0**
Bratton Camp	**1**	**0**	**0**	**0**	**0**	**0**
Broadsands	**6**	**0**	**0**	**0**	**0**	**0**

Chestnuts	7	0	0	0	0	0
Figheldean Down (31)	1	0	0	0	0	0
Fittleton Down (5)	1	0	0	0	0	0
Fromefield	18	0	0	0	0	0
Fyfield (Giants Grave)	2	0	0	0	0	0
Gatcombe Lodge	1	0	0	0	0	0
Giant's Hills (Skendleby I)	6	4	0	4	0	66.7%
Haddenham	5	0	0	0	0	0
Handley 26	1	1	0	0	0	100%
Handley 27	1	0	0	0	0	0
Hazleton North	41	3	0	3	0	7.3%
Hetty Pegler's Tump (Uley)	5	2	0	2	0	40%
Horton Down (Bishops Cannings 91)	1	0	0	0	0	0
Imber (Bowls Barrow)	5	3	1	3	0	60%
Jackbarrow	3	0	0	0	0	0
Kings Playdown (Heddington 3)	1	0	0	0	0	0
Lamborough Banks (Ablington)	1	0	0	0	0	0
Lanhill	8	0	0	0	0	0
Littleton Drew (Lugbury)	12	8	2	7	0	66.7%
Luckington (Giants Cave)	11	0	0	0	0	0
Millbarrow	8	0	0	0	0	0
Netheravon Down (6)	2	1	0	1	0	50%
Norton Bavant	12	1	1	1	0	8.3%
Nympsfield	9	0	0	0	0	0
Oldbury Hill	3	0	0	0	0	0
Randwick	3	2	2	2	0	66.6%
Rodmarton	12	3	0	3	0	25%
Stonehenge (Amesbury 14)	3	2	0	2	1	66.6%
Stoney Littleton	2	0	0	0	0	0
Tilshead East (7)	8	4	0	3	1	50%
Tilshead Lodge	2	0	0	0	0	0
Tilshead Old Ditch	1	0	0	0	0	0
West Tump (Cranham)	1	0	0	0	0	0
Winterbourne Monkton	22	11	5	9	2	50%
Wor Barrow	7	0	0	0	0	0
West Kennet	42	6	4	4	5	14.3%
TOTALS	305	61	20	50	9	20%

When the TPR is calculated for sex, females have a higher prevalence of porotic hyperostosis than males. Sixteen females had the condition, which equates to 48% (16/33 whole female crania), and males had 34% (15/44 whole male crania). However, when the rates are calculated for the three most affected areas of the cranium (parietal, frontal and occipital), the figures differ. The prevalence rate of porotic hyperostosis of the parietal is 13.6% for males (13/96) and 16.9% for females (13/77). The TPR for the frontal is 12% for males (8/66) and 8.3% for females (4/48) and 11% for males (5/45) and 3% for females (1/38) for the occipital. Interestingly, nine individuals exhibited signs of both cribra orbitalia and porotic hyperostosis (Table 6.5), reflecting a diet deficient in animal protein and Vitamin C, together with weaning foods that are deficient in nutrients. Additionally, the female individual from Imber (Bowl's Barrow EU.1.5.78) also exhibited EH (enamel hypoplasia) on the left maxillary canine.

Table 6.5: Individuals suffering from both cribra orbitalia and porotic hyperostosis

Site	Male	Female
Belas Knap # 2		✓
Belas Knap # 9		✓
Hazleton North # 10213		?
Imber, Bowl's Barrow EU. 1.5.78		✓
Imber, Bowl's Barrow EU. 1.5.79		?
Littleton Drew EU. 1.5.57	?	
Randwick	✓	
Tilshead East EU.1.5.70	?	
Tilshead East EU.1.5.72	?	

6.3: Summary

This chapter outlines nine new cases of metabolic disease for the Neolithic period, affecting 2.95% of the individuals studied (9/305) and 83 new cases of non-specific indicators of stress, affecting 27% (83/305) of those individuals studied. Six new cases of scurvy were presented from three sites, giving a CPR of 2%. All of the cases involved infants or children no older than eight years of age, who all exhibited porosity and new bone formation on the cranium or mandible, and in the case of the infant from Fromefield (Skeleton # 1), also had evidence of porosity on all of the extant long bones. In addition, this individual also had endocranial lesions on the parietal bone. The fact that three of the individuals with evidence of scurvy were infants indicates that there was insufficient vitamin C in the breastmilk, and that these individuals themselves were possibly suffering from scurvy.

The nine month old baby may have had a limited vitamin C intake initially, but a deficiency of the nutrient took a few months for the recognisable signs of the disease to appear. The remaining two older children, aged between five and six years, and about eight years old at death, would have long past the weaning stage and would have needed a regular intake of vitamin C to avoid scurvy. It is interesting to note that four of the six individuals (67%) with scurvy from this study all came from the same site, Hazleton North long barrow. Furthermore, the mother of the infant would also likely have been suffering from the disease, indicating that five individuals out of the forty-one present at the site (12%) had a vitamin C deficient diet, which would have been a significant problem in the past.

One child of about four and a half years from the current study had a possible case of rickets, visible on the right femur, giving a CPR of 0.3% (1/305). The bone had disordered swelling and flaring of the metaphysis and angulation of the growth plate, together with roughening, cupping and macroporosity on the diaphyseal bone underlying the epiphyseal growth plate. The affected individual may have spent prolonged periods within the dwelling, either due to illness or disability, unable to absorb ultra-violet light from the sun's rays, the most efficient way of synthesising vitamin D.

Two mature adults from the current study may have suffered from primary osteoporosis, giving a CPR of 0.6%. This type of osteoporosis is age-related, and causes the characteristic changes in the skeleton due to a drop in sex hormones. A male exhibited very lightweight and porous elements, atrophied vertebral bodies, and a fracture to a rib, together with cortical thinning of the femora and right tibia, and may have suffered from Type II osteoporosis, which affects both males and females. A female had suffered a Colles' fracture to the distal radius, a common site of traumatic injuries sustained by osteoporotic individuals who suffer from the Type I form of the disease.

Cribra orbitalia and porotic hyperostosis are considered non-specific indicators of physiological stress and were both more prevalent in the skeletal assemblages than metabolic diseases. Twelve of the 42 sites studied produced evidence of cribra orbitalia (29%), consisting of 21 individuals, giving a CPR of 7% and a TPR of 14.6% (with rates of 13.9% for males and 15% for females when the TPR is calculated by sex). These figures are lower than those given by other researchers for the period, and this may be due to differing diagnoses of the conditions found. Porotic hyperostosis was evident at 15 of the 42 sites (36%) and affected 61 individuals, giving a CPR of 20% of the population. When the TPR is calculated by sex, males had a higher prevalence in two regions of the cranium, the frontal and occipital. The TPR for each region of the cranium was: 13.6% for males and 16.9% for females (parietal); 12% for males and 8.3% for females (frontal); and 11% for males and 3% for females (occipital). Interestingly, nine individuals from six sites suffered from both conditions, perhaps reflecting inefficient subsistence practices, leading to a poor diet, poor sanitation and infectious diseases, with one individual also exhibiting EH.

Chapter 7: Infectious Disease

7.1: Introduction

According to the World Health Organization, the most common causes of death globally in 2015 were ischaemic heart disease and strokes, accounting for 15 million out of the 56.4 million deaths that year (WHO, 2017). However, before the introduction of antibiotics during the 1940s, infectious diseases were thought to be responsible for killing half of the population before sexual maturity could be reached, and those who lived into adulthood, were very likely to die of infectious disease or complications arising from it (Ortner 2003: 180). The introduction of agriculture in the Neolithic period, not only brought about changes in subsistence and world view, but necessitated the need for sedentism, larger populations to tend the crops, and animal husbandry, all of which encouraged the spread of infectious diseases that had not been prevalent in previous periods (Barrett *et al*. 1998: 252). Furthermore, as time progressed, the ability of epidemics to eradicate half of the population in densely inhabited cities, illustrates the more negative aspects of communal living without the benefit of effective medical treatment and sanitary conditions (Waldron 2009: 84).

The study of infectious disease in human skeletal material gives valuable insights into the evolution and spread of certain diseases in the past which can be treated with antibiotics today, such as tuberculosis, leprosy and treponematosis, thereby allowing management of these diseases (Roberts 2000: 146). However, many infectious diseases in the past were so acute and acted so swiftly, that the pathogens that caused them left no trace on the skeletal tissues (Ortner 2008: 191). Furthermore, even in chronic infectious disease, where the skeleton can develop obvious evidence of pathological activity, only a small percentage of individuals will have skeletal involvement, for example, between 3% and 5% in tuberculosis (Resnick 2002a: 2524). Nonetheless, the disorders that can involve the skeletal tissues and that are caused by pathogenic organisms such as bacteria include: osteomyelitis; tuberculosis; leprosy; treponematosis; and brucellosis (Ortner 2008: 192). In addition, smallpox and polio (viruses); mycosis and mycosis-like diseases (fungi); echinococcosis (parasites) and periostosis (a pathological lesion) can leave visible evidence on skeletal tissue (Waldron 2009: 84).

Not everyone who is exposed to a bacterial or viral agent will be susceptible to it, and an individual's response is dependent upon several intrinsic (host) and extrinsic (environmental) factors: pathogenicity of the agent (the capability of an organism to cause to disease); the way in which the disease is transmitted; the host's response to the infection; age; sex; genetic predisposition; nutritional health at onset of infection (those suffering from malnutrition are more susceptible to infection); occupation; extent of contact with others through trade etc.; population density; sanitation and living conditions (Inhorn and Brown 1997: 32-33; Bannister *et al*. 2006: 7).

When an individual is targeted by an infecting agent, the body responds with inflammation at a cellular level, causing the release of antibodies and leukocytes into the bloodstream to fight the infection, with the severity of the response proportional to the quantity and virulence of the infecting organisms (Parkin and Cohen 2001: 1777). The immune response to infection will usually have two outcomes on the skeleton – bone formation or bone destruction, or a mixture of both, and the speed with which the lesions are formed, dictates the morphology of the lesion: rapid bone formation produces woven bone, which will over time (in chronic infections) produce compact bone; rapid destruction of bone will produce lesions with poorly defined margins, whereas chronic destruction of the bone causes lesions with sclerotic margins (Ortner 2008: 193).

7.2: Bacterial Infection

7.2.1: Osteomyelitis

Osteomyelitis is characterised by infection of the bone and bone marrow, resulting in inflammatory bone destruction (Resnick 2002b: 2378). The pyogenic (pus-forming) bacteria can reach bone by three different routes: through the bloodstream (haematogenous route) from a remote septic focus; by direct infection, introduced by traumatic (compound fracture, for example), or penetrating injuries (animal bites, stab wounds etc.); or by direct spread from overlying infected soft tissue (Mast and Horowitz 2002: 232; Resnick 2002b: 2379). The haematogenous route is the most common way that pyogenic bacteria are disseminated around the body, and in 90% of cases, *Staphylococcus aureus* is the causative organism (Lew and Waldvogel 2004: 370). In clinical medicine, osteomyelitis is most common in children between the ages of three and 15, but in past populations before the advent of antibiotics, adults found with the condition, may have been suffering from a long-standing, chronic infection, left-over since childhood (Rogers and Waldron 1989: 612). Indeed, although the organisms that cause osteomyelitis can remain active for many years, and although in some cases, the disease can re-occur, it was not always fatal - the mortality rate cited in pre-antibiotic literature varies from 2.8% to 4.5% (Amberg and Ghormley 1934: 184).

The areas of the skeleton that are most affected by osteomyelitis in childhood are the long, cylindrical bones of the appendicular skeleton, particularly the knee region, the distal end of the tibia and proximal end of the femur (Rogers and Waldron 1989: 612). However in adults, the axial skeleton is most commonly affected (Resnick 2002b: 2380). In children, the infection often occurs in the metaphysis, adjacent to an actively growing end-plate (Roberts and Manchester 2010: 171). As soon as the bacteria enter the medullary cavity, a period of rapid proliferation ensues, stimulating a swift immunological response, with the production of pus, and a resulting rise in volume and pressure within the narrow shaft (Salter 1999: 210). The rise in pressure causes necrosis of the cortex, and isolated fragments of dead bone (sequestra) are rapidly surrounded by osteoclasts which attempt to destroy the tissue - if the fragment is small enough, it can pass through a hole, or cloaca, which also drains the pus from the cavity (Ortner 2008: 195). Large sequestra cannot pass through the cloaca or be reabsorbed, thereby maintaining an infective presence which will continue to proliferate until surgical removal, or even death (Ortner 2003: 182). The presence of organisms beneath the periosteum that surrounds the cloaca initiates the formation of extensive new bone, which can form a thick layer encompassing the diaphysis, called the involucrum (Lew and Waldvogel 2004: 370). The presence of one or more cloacae, sequestra, and involucrum are pathognomonic for chronic pyogenic osteomyelitis (Waldron 2009: 86).

The clinical symptoms of acute haematogenous osteomyelitis in children are a high fever, lethargy, irritability, inflammation in the affected area, and a limp if the lower limb is involved, although all of these signs are not always present, with some children only suffering from a mild fever and vague joint pain (Calhoun *et al*. 2009: 62; Harik and Smeltzer 2010: 3). Adults may also present with a fever, chills, inflammation and a rash-like area (erythema) over the affected bone in acute cases, but a low fever lasting a few months, accompanied by non-specific pain may be signs of re-occurring osteomyelitis (Calhoun *et al.* 2009: 62). In most modern cases, treatment with antimicrobial drugs and surgical removal of infected and necrotic tissue should be considered (Lew and Waldvogel 2004: 374).

One individual in the current study exhibited a probable case of osteomyelitis, giving a CPR of 0.3% (1/305) and a TPR of 0.9% (1/106). The adult individual from West Kennet long barrow (no number specified) was represented only by a partial left fibula. A cloaca, measuring 5.1mm medio-laterally and 8.7mm supero-inferiorly is present on the lateral distal end of the bone. The opening is ovoid in shape with smooth edges and is surrounded by new bone formation and porosity, indicative of increased vascularity in this location (Figure 7.1). There is no evidence of a fragment of sequestrated bone, but given that the cloacal opening is only small, it could have either been reabsorbed during osteoclastic activity, or passed through the opening with the exudate.

Figure 7.1: A - Left fibula from an adult from West Kennet long barrow, with cloaca (red arrow) and new bone formation surrounding the opening. B – Detail.

7.2.2 Periosteal New Bone Formation

The periosteum is a membranous tissue that completely covers the outer surface of bone, except in the areas where the bone is overlain by other tissues such as articular cartilage, synovial membrane, or where the bone forms part of a non-synovial joint such as the pubic symphysis (Waldron 2009: 115). The membrane consists of two layers: an outer fibrous layer which is rich in blood vessels, fibroblasts and Sharpey's fibres which provide anchorage of the periosteum to the underlying bone; and the inner layer, which contains nerves, capillaries, undifferentiated mesenchymal cells which have the ability to differentiate into cartilage or bone forming cells, and growth factors, which are vital for healing and the remodelling of new bone (Malizos and Papatheodorou 2005: S14).

Areas of periosteal new bone are often exhibited on the long bones in skeletal assemblages, especially on the tibiae, in the form of a grey-coloured woven bone, which given time and healing, will remodel into lamellar bone (Weston 2008: 48). The presence of periosteal new bone on an element, does not however necessarily indicate that the reaction was caused by infection: inflammation of the periosteal membrane may also be triggered in cases of trauma and neoplastic disease (Ortner 2008: 196). Furthermore, any mechanism that causes breakage, tears, stretching or even touching of the periosteal membrane can stimulate new bone formation (Richardson, 2001). Studies by Weston (2008, 2009) revealed that macroscopic, microscopic and radiographic analysis of clinical specimens from pathology museums indicated that it was not possible to determine the characteristic periosteal lesions to a specific disease. It has therefore been suggested by Ortner (2008: 196) that unless the periosteal new bone can be directly related to an infectious agent (such as an area of focal periostitis associated with an overlying ulcer, for instance), then the term periostosis or periosteal new bone formation should be used to describe a bone-forming abnormality of the outer bone surface.

In the current study, four disarticulated bones which are not assigned to any particular individuals were found to exhibit areas of periosteal reactive bone. Three of the bones were from the same site and context, allowing the possibility that they derived from the same individual. Therefore the CPR for the condition at all sites is 0.7% (2/305). The bones from the two sites include: two fibulae (distal diaphysis affected), giving a TPR of 1.9% (2/106) for that element; an adult tibia (distal diaphysis affected), giving a TPR of 0.8%, (1/118) for that element; and an adult femur (proximal diaphysis affected) giving a TPR of 0.9% (1/115).

The first case of periosteal new bone formation is from a disarticulated partial fibula from an adult excavated from Broadsands long barrow (#A3038.38). The distal right fibula has an area of lamellar bone on the medial side, measuring 15mm supero-inferiorly by 15mm antero-posteriorly at the site where the interosseous ligament attaches the bone to the tibia at the ankle joint (Figure 7.2). It is possible that the periosteal new bone formation is caused by infection, but it may also have been caused by trauma, but without the corresponding tibia, it is difficult to ascertain.

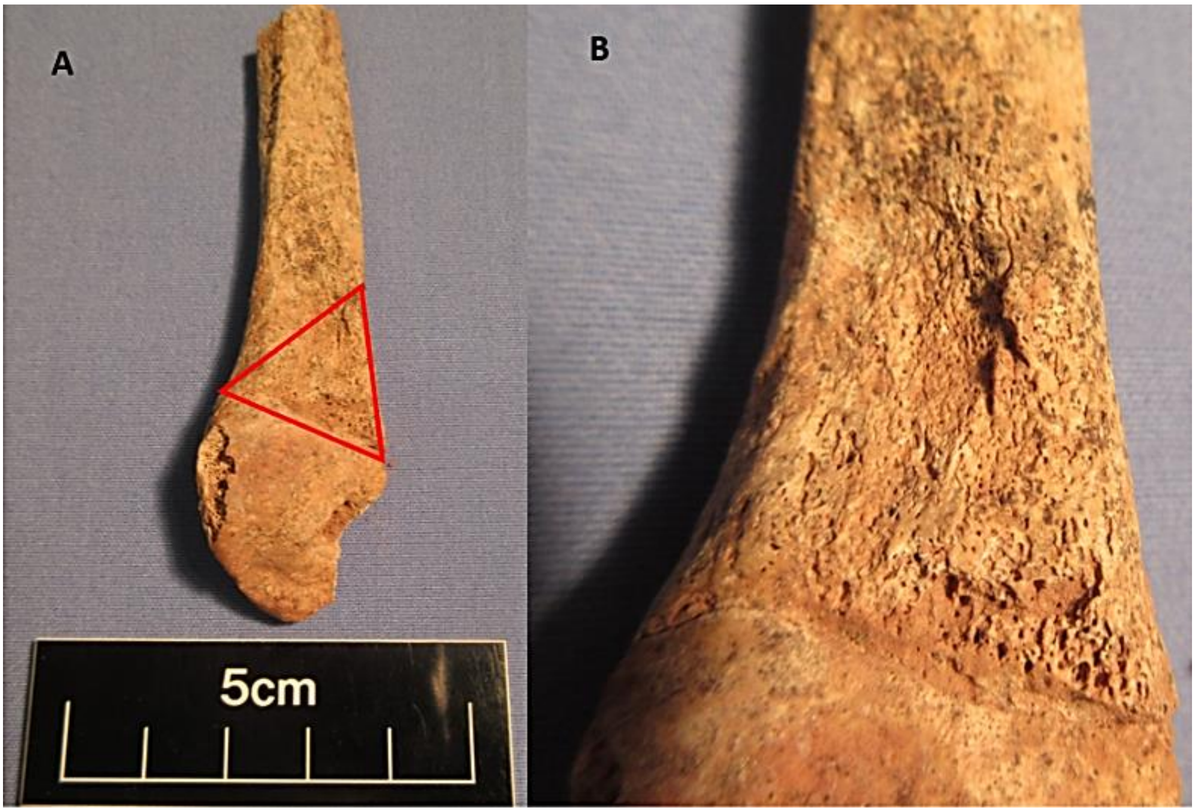


Figure 7.2: A - Right fibula from Broadsands long barrow (# A3038.38) with periosteal new bone formation to the distal end (affected area in red triangle). B- Detail.

The three remaining cases of periosteal new bone formation were all excavated from Hazleton North long barrow, and are disarticulated bones. A right fragmented adult fibula (# 4931), only represented by the distal diaphysis, has an slight deposit of woven new bone on the medial aspect measuring approximately 30mm supero-inferiorly by 10mm antero-posteriorly, in the area where the interosseous ligament attaches to the tibia (Figure 7.3A).

Figure 7.3: A – Right distal fibula (#4931) from Hazleton North long barrow with area of periosteal new bone formation on medial surface. B – Right tibia from Hazleton North long barrow (#8817) with large area of woven new bone on anterior, partially broken off post-mortem. C- Left femur from Hazleton North long barrow (# 8816), with area of woven new bone on posterior surface.

A right adult tibia (# 8817) has a large area of woven new bone on the anterior aspect of the distal diaphysis of the tibia, which has unfortunately been damaged post mortem. The affected area measures approximately 45mm supero-inferiorly and 40mm medio-laterally and is evident in a loose plaque-like formation, adhering to the cortical bone (Figure 7.3B). The last bone affected with periosteal new bone formation from this site is a left adult femur (# 8816), which exhibits a large area of woven new bone measuring approximately 60mm supero-inferiorly and 30mm medio-laterally on the posterior of the femoral shaft, in the area of the linea aspera (Figure 7.3C). The new bone is loose and plaque-like. All of the bones featured in Figure 7.3 may exhibit periostitis due to infection, but localised trauma could also have caused these pathological lesions.

7.2.3: Otitis Media

Otitis media is an infection of the middle ear and is one of the most common childhood infections, accounting for 10% of all cases seen in clinical paediatric medicine today (Daniel *et al.,* 1988: 143). In fact, in a study of over 600 children from Boston, Teele *et al.* (1989: 90) found that by the age of one year, 60% of the group had experienced more than one episode of acute otitis media, and 17% had experienced more than three episodes. Furthermore, the study reported that by the age of three years, more than 80% of the group had suffered from the disease, and more than 40% had had three episodes or more (Teele *et al*. 1989: 90). The disease may be acute or chronic in nature and is largely caused by the pneumococcus *Streptococcus pneumoniae, Haemophilus influenzae* and *Moraxella catarrhalis* (Rovers *et al*. 2004: 466). Acute otitis media occurs when bacteria accumulate in the tympanic cavity, which is accessed via the Eustachian tube, causing inflammation of the mucous membrane (Flohr and Schultz 2009: 266). An effusion (a thick, sticky fluid) can be produced, followed by pus which fills the cavity, causing the tympanic membrane to redden and extrude into the external auditory canal, and which may eventually perforate, allowing the exudate to drain (Aufderheide and Rodríguez - Martin 2011: 253). Chronic otitis media may last past childhood, when bacterial agents such as *Pseudomonas aeruginosa* or *Staphylococcus aureus* gain access to the middle ear through the perforated tympanic membrane during bathing or swimming, or via the Eustachian tube from nasopharyngeal secretions, as the pressure within the middle ear has been compromised due to the perforation of the tympanic membrane (Bluestone 1998: 214).

New bone formation on the endocranial surface of the cranium is a good indicator of otitis media but the use of radiography is useful to confirm the diagnosis of the disease, the osseous signs of which are: inadequate aeriation or altered mastoid development; incomplete pneumatisation (the formation of air cavities) in the temporal bone; perforations of the mastoid; bone-invading chronic suppurations; and malalignment, erosion or complete necrosis of the ossicles (Daniel *et al.* 1988: 158).

The prevalence of chronic suppurative otitis media today is markedly different within different racial and cultural groups, and can be separated into four main categories: highest prevalence – the Inuit of Alaska, Canada and Greenland, Australian Aborigines, and Native Americans (Apache and Navajo); high prevalence – indigenous people of the Solomon Islands, New Zealand Maori, Malaysia, and Micronesia, and some African populations (Sierra Leone, Gambia, Kenya, Nigeria, and Tanzania); low prevalence – Korea, India, and Saudi Arabia; and the lowest prevalence – USA, UK, Denmark, and Finland (Bluestone 1998: 209). The reasons why some populations are at more risk than others to develop and have re-occurring episodes of otitis media are thought to be due to anatomical differences in the craniofacial structure of some groups, but other factors such as genetic predisposition, and environmental factors such as parental smoking, poverty, diet and lack of breastfeeding for babies are significant (Shultz 1979: 578; Bluestone 1998: 215; Rovers *et al*. 2004: 467).

The clinical symptoms of acute otitis media are the rapid onset of otalgia (ear pain), otorrhoea (ear discharge), fever, and irritability, which may be reduced by the use of antibiotics or surgery (Rovers *et al*. 2004: 465). Complications of acute otitis media are: hearing loss due to destruction of the ear ossicles, which in turn has a negative impact on speech development; the increased risk of re-occurrence of the disease; perforation of the tympanic membrane; meningitis; and septicaemia (Daniel 1998: 143).

In the current study five adult individuals exhibited macroscopic evidence of middle ear infection (new bone formation on the petrous temporal bone), three of which were verified by CT scans. A further individual was diagnosed with otitis media from a CT scan that had been taken to diagnose a different condition. Therefore, six individuals are considered to have suffered from chronic otitis media (four with CT scan evidence), giving a CPR of 2% (6/305). In the course of the current study, 117 left, and 112 right temporal bones were available, but of these, only 94 left, and 94 right petrous bones were visible. The six individuals affected by otitis media had a total of eight affected petrous bones (Table 7.1), giving a TPR of 2.1% (2/94) for the left petrous temporal bone, and 6.4% for the right (6/94). When the TPR is calculated by sex, the left petrous temporal is 6.3% (2/32 female left petrous temporal bones). The TPR for the right temporal is 5.6% for males (2/36 male petrous temporal bones) and 10.3% for females (3/29).

Table 7.1: Individuals affected by otitis media.

Site	Sex	Age	Left Petrous Bone	Right Petrous Bone
Belas Knap # 6	M	45+		✓
Belas Knap # 8	F	39-56		✓
Belas Knap # 10	M	45-51		✓
Bown Hill # EU1.5.138	?	?		✓
Lanhill # EU1.5.105	F	50+	✓	✓
Rodmarton # 80	F	48-56	✓	✓
TOTAL			2	6

A mature male of about 45 years of age from Belas Knap long barrow (# 6) exhibits macroporosity and new bone formation on the right petrous temporal bone, on the superior surface of the petrous pyramid (Figure 7.4A). A CT scan of the cranium (Figure 7.4B) reveals density surrounding the whole ear structure, where the ear cells have coalesced and there is diffuse thickening of the cortex which overlies the mastoid, consistent with otitis media (pers. comm. Iain Watt, Consultant Radiologist).

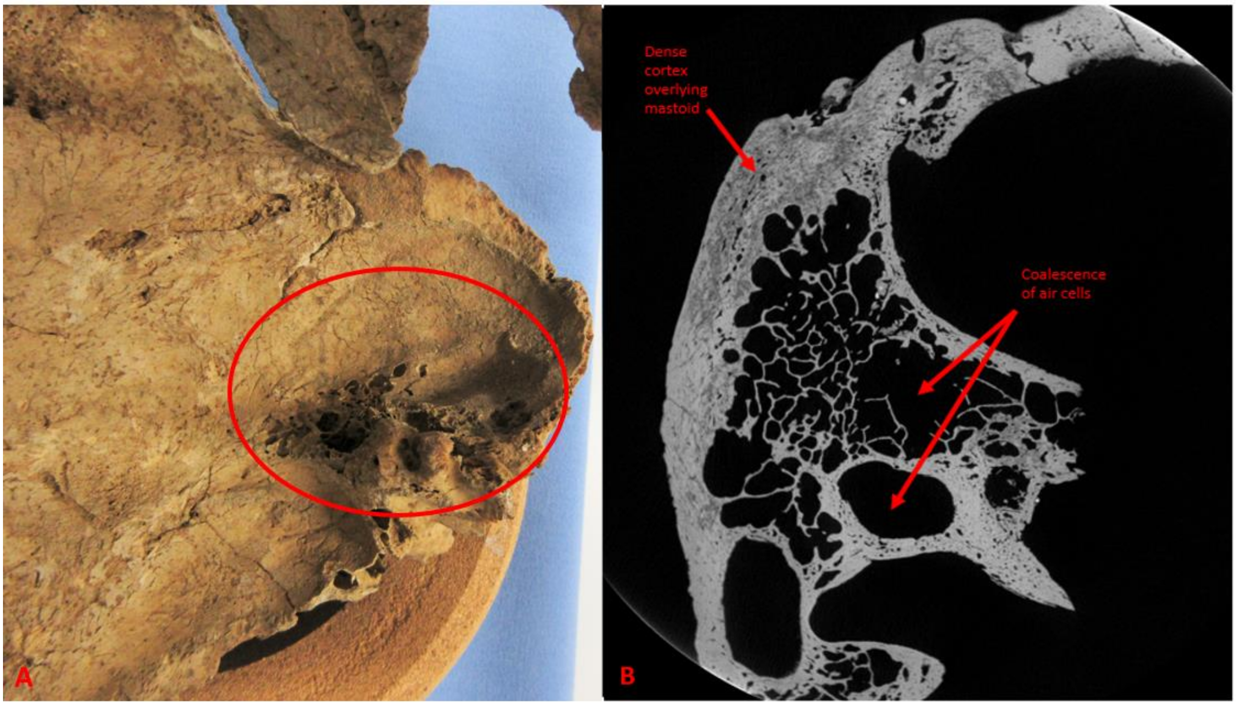


Figure 7.4: A- Medial (endocranial) view of left petrous bone of individual # 6 from Belas Knap long barrow, anterior to the right, superior is up. Red circle surrounds area of macroporosity and new bone formation. B – CT scan (axial view) of same individual showing coalesced air cells and dense cortical bone overlying the mastoid (red arrows).

A mature adult female of between 39 and 56 years of age, also from Belas Knap long barrow (# 8), has an area of macroporosity and new bone formation on the superior aspect of the petrous pyramid (Figure 7.5A). A CT scan (Figure 7.5B) shows total destruction of the cochlea, abnormally large and distorted semi-circular canals, coalescence of the mastoid air cells where the normal architecture has been destroyed and may have become pus-filled, and large areas of sclerotic bone. Furthermore, the gross disruption that this individual would appear to have suffered to the middle ear would have resulted in deafness (pers. comm., Iain Watt, Consultant Radiologist).

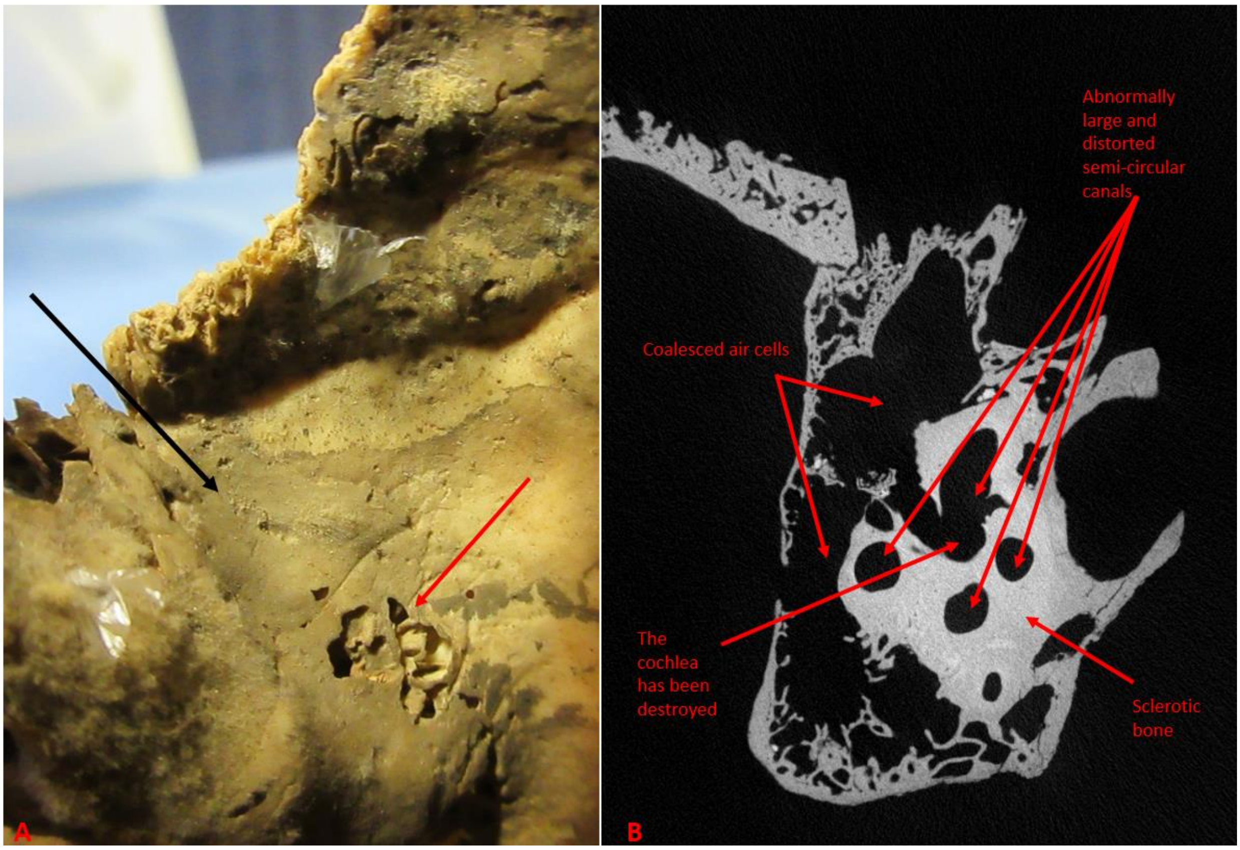


Figure 7.5: A – Medial view of adult female from Belas Knap long barrow (# 8) with new bone formation (black arrow) and macroporosity (red arrow) on endocranial surface of the right temporal bone. B- CT scan (axial view) of the same individual, showing destruction of middle ear and mastoid cells.

A third individual from Belas Knap long barrow (# 10), a male aged between 45 and 51 years of age, is also considered to have suffered from otitis media. Figure 7.6A shows an area of new bone formation and macroporosity on the superior aspect of the right petrous temporal. A CT scan (Figure 7.6B) of the affected area shows a view of the semi-circular canals, which are enlarged, surrounded by dense sclerotic bone, and a thickening of the mastoid air cells with simplification of pattern (pers. comm., Iain Watt, Consultant Radiologist).

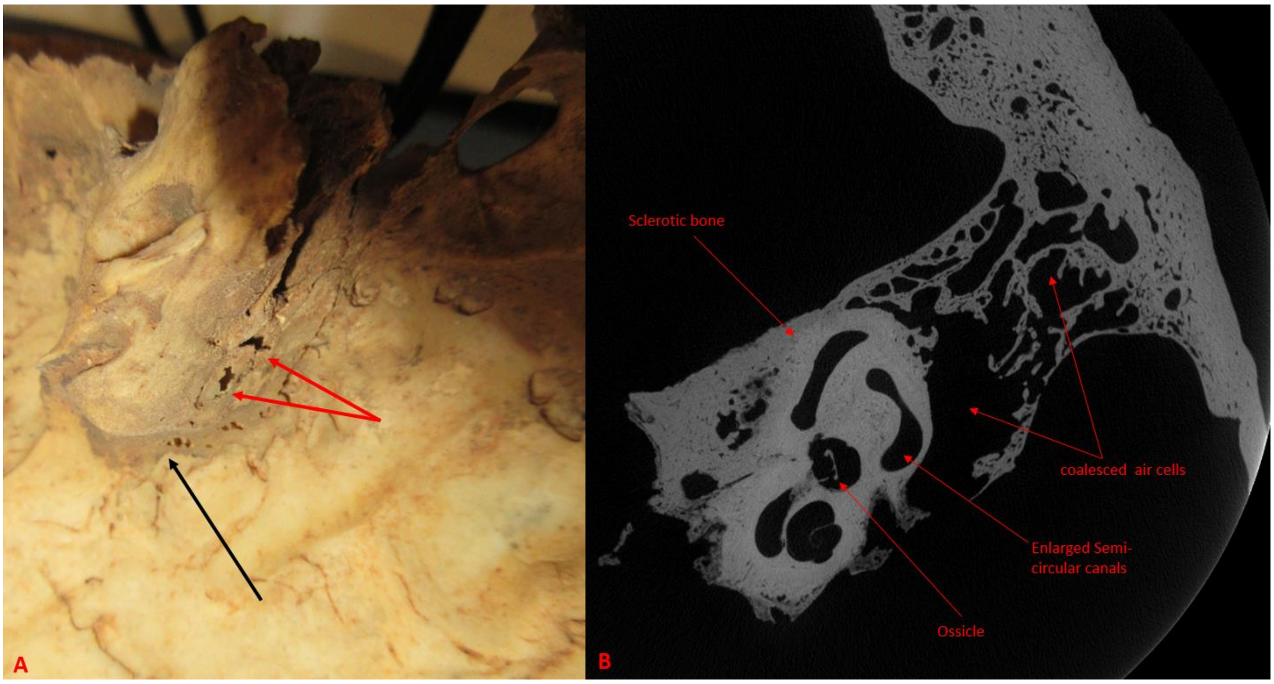


Figure 7.6: A – Right petrous temporal bone of Belas Knap # 10, showing new bone formation (red arrows) and macroporosity (black arrow) on superior aspect of petrous pyramid. B- CT scan of the same individual showing otitis media of the middle ear in the form of sclerotic bone, abnormal semi-circular canals, and coalesced air cells of the mastoid.

An elderly female, aged at least 50 years, from Lanhill long barrow (# EU 1.5.105), has evidence of ear infection in both the right and left temporal bones. Neither of the petrous temporal bones are visible, as the cranium is intact, and she was not therefore originally identified as suffering from otitis media. However, this individual was selected for CT scanning as she manifested interesting circular lesions on many of her long bones, pelvis and cranium, which on inspection of the CT scans, were found to be non-pathological (pers. comm. Iain Watt, Consultant Radiologist). Figure 7.7 shows a CT scan of both temporal bones. The images detail sclerotic bone on both of the petrous aspects of the temporal bones and rather irregular and ill-defined cochleae and semi-circular canals, which suggest chronic otitis media (pers. comm. Iain Watt, Consultant Radiologist). In addition, this individual exhibits large areas of fragmented air cells in the mastoid process on the left side, which may be taphonomic, but the cranium of this individual is mostly complete, and the petrous temporal bones would be protected, suggesting that the presence of the fragmented air cells are likely to be pathological and linked to the chronic otitis media suffered by this individual.

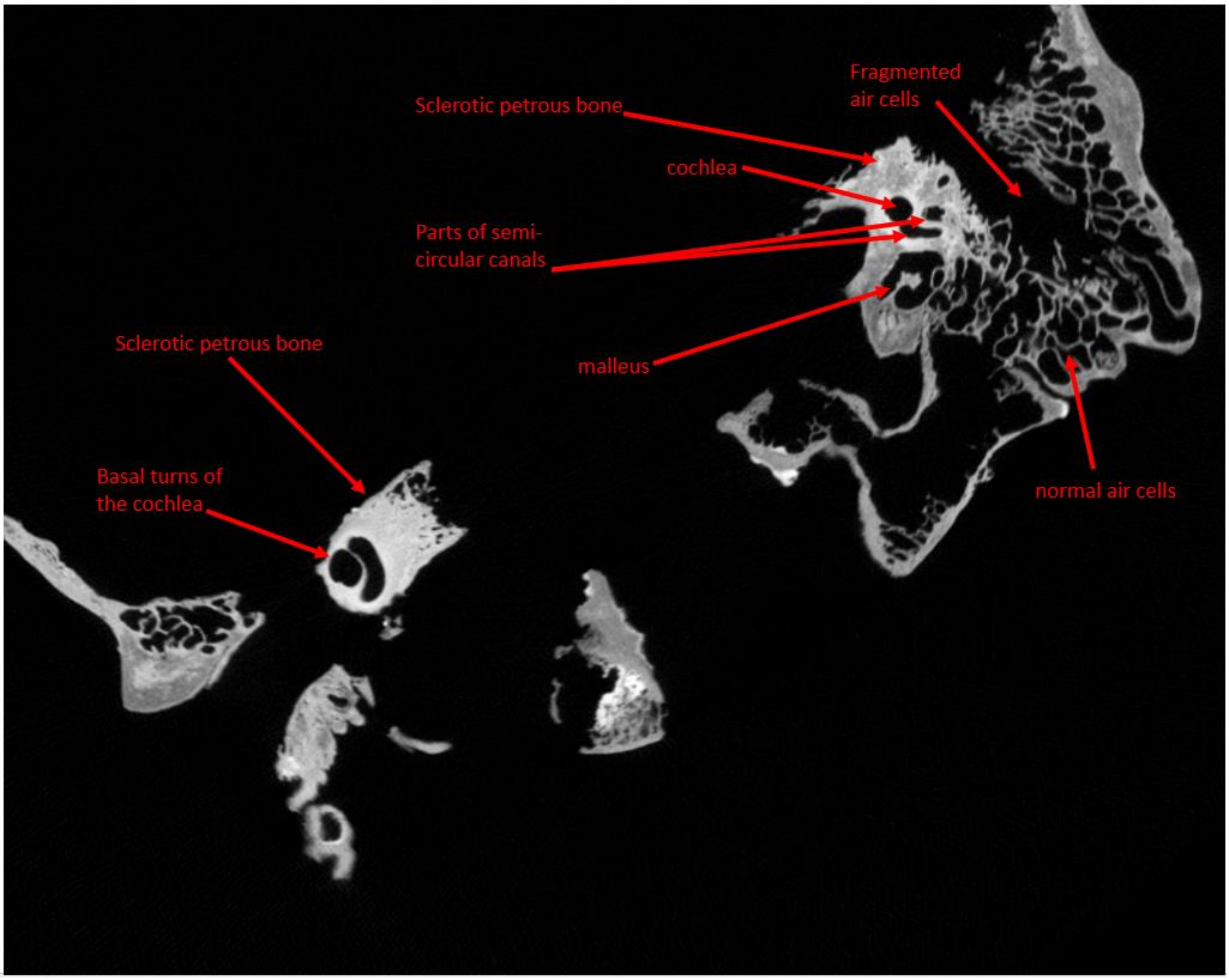


Figure 7.7: Left and right temporal bones of elderly female from Lanhill long barrow (EU 1.5.105) with evidence of otitis media in both bones in the form of sclerotic bone, irregular and ill-defined cochleae and semi-circular canals, and fragmented air cells of the mastoid (left temporal bone).

An adult individual of unknown age or sex, from Bown Hill long barrow (# EU. 1.5.138), represented only by fragments of cranium, exhibits a right temporal bone with an area of macroporosity, surrounded by discrete area of remodelled new bone on the superior surface of the petrous pyramid (Figure 7.8). The macroscopic appearance of the affected area is very similar to those individuals from Belas Knap who are considered to have suffered from otitis media. However, the individual from Bown Hill long barrow was not selected for a CT scan, due to the limit of specimens allowed to be removed from the facility, thereby making a definite diagnosis of otitis media difficult. Nevertheless, the area of macroporosity and remodelled new bone on the petrous temporal are highly suggestive of otitis media.

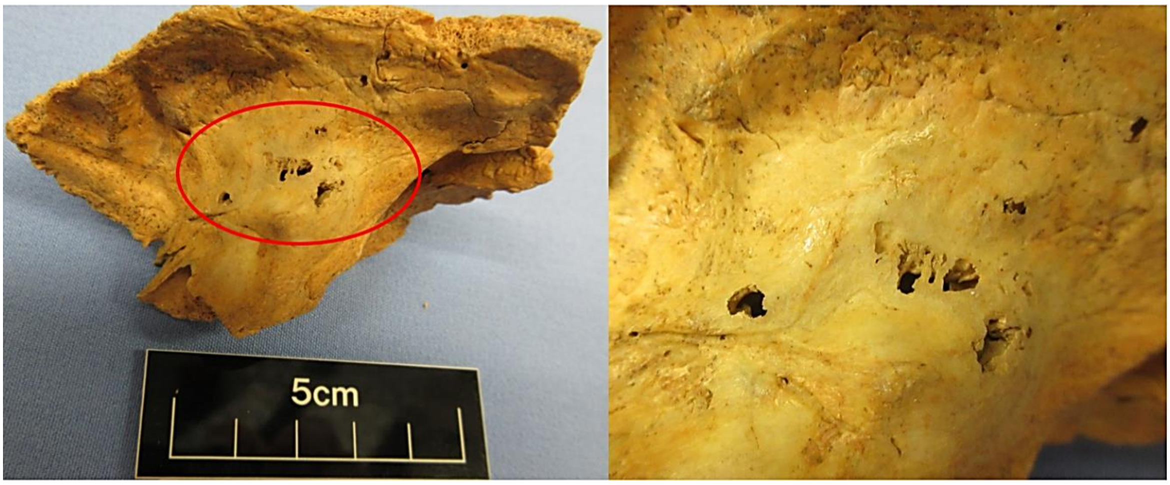


Figure 7.8: Left - An adult individual of unknown age or sex from Bown Hill long barrow (EU. 1.5.138) exhibiting macroporosity and remodelled new bone on superior surface of the right petrous pyramid. Right – detail.

One more individual who may have suffered from otitis media is a mature adult female, aged between 48 and 56 years of age, from Rodmarton long barrow (# 80). The cranium of this individual is very fragmented but both temporal bones are present and both the left and right petrous portions show signs of the disease, in the form of dense porosity and new bone formation (left side only) (Figure 7.9). Whilst the right temporal does exhibit porosity, it has a rather ragged appearance, and it could be argued that the lack of new bone formation on the superior surface perhaps suggests that this may be due to taphonomic processes. Unfortunately, this individual was also not selected for a CT scan for the same reasons as above, rendering a definite diagnosis of otitis media difficult.

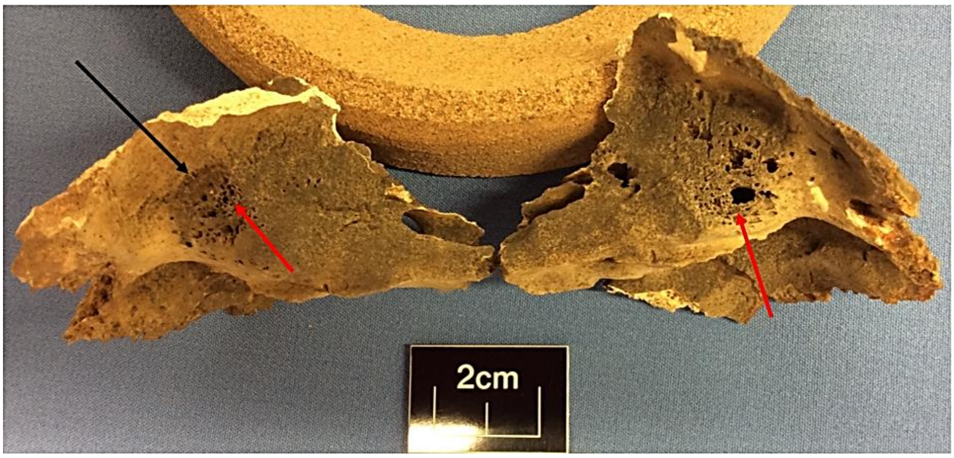


Figure 7.9: Mature adult female from Rodmarton long barrow (# 80) with areas of dense porosity (red arrows) and new bone formation (black arrow) on the superior aspects of the temporal bones, indicative of otitis media.

7.2.4. Meningitis

Meningitis is the inflammation of the meninges of the brain and spinal cord, and the bacterial form is still a significant cause of morbidity and mortality today (Nudelman and Tunkel 2009: 2578). Historically, the most common pathogens that cause the disease are *Haemophilus influenzae*, *Neisseria meningitidis*, and *Streptococcus pneumoniae,* but the recent introduction of the *H. influenzae* vaccine has seen a remarkable decrease in the disease, from between 45% and 48%, to 7% today (Brouwer *et al*. 2010: 468). Furthermore, the routine vaccination of babies at two, three and four months of age with the meningococcal C vaccine has seen further reductions in the prevalence of the disease (Brouwer *et al*. 2010: 471). *Streptococcus pneumoniae* is the most common cause of bacterial meningitis today and has over ninety different antigenic serotypes, which make it a very difficult disease to control – currently, the most effective vaccine only covers 23 of these serotypes (McGill *et al*. 2016: 3036). In areas of the world without routine vaccination programmes, such as in developing counties and in particular, sub-Saharan Africa (known as the meningitis belt) the prevalence of bacterial meningitis is still significant – the incidence for areas of Niger between the period of 1981 to 1996 for meningococcal meningitis was 101 cases per 100,000 population (Brouwer *et al*. 2010: 468).

The pathogenesis of bacterial meningitis follows four main steps: mucosal colonisation; systemic invasion; survival in the bloodstream; and invasion into the subarachnoid space, which causes intracranial pressure from the inflammatory response triggered by the replication of the bacterial agents (Nudelman and Tunkel 2009: 2582). The majority of cases of bacterial meningitis occur following bacteraemia (the presence of bacteria in the blood), but direct spread into the central nervous system is suggested by the high prevalence of the disease in patients also suffering from sinusitis and otitis media (McGill *et al*. 2016: 3038). The clinical manifestations of the disease can be difficult to identify in neonates and infants; patients may present with vomiting, lethargy, fever, irritability and poor feeding, but older children are more likely to present with the more publicized symptoms of vomiting, photophobia, neck stiffness, and headache, whereas adults often present with only two of the classic signs of the disease (Brouwer *et al.* 2010: 472-3). Diagnosis of bacterial meningitis is performed by examination of the cerebrospinal fluid by lumbar puncture (Nudelman and Tunkel 2009: 2584).

One individual in the current study is suspected of having meningitis, giving a CPR of 0.3% (1/305) and a TPR of 1.8% (1/55). The adult male, aged about 45 years at death, was excavated from Belas Knap long barrow (# 6), and also suffered from otitis media (featured in Figure 7.4.). This individual has two raised plaques of new bone on the endocranial surface of the cranium, adjacent to the left orbit. The largest plaque measures a maximum of 20mm medio-laterally, and 8mm antero-posteriorly and lies adjacent to the frontal crest and the wall of the left orbit. The smaller plaque measures a maximum of 5mm medio-laterally and 2mm antero-posteriorly and lies adjacent to the larger plaque and to the left orbital wall (Figure 7.10). These plaques of new bone on the endocranial surface represent inflammation and are suggestive of non-specific (i.e. bacterial) meningitis (Schultz 2001: 123). The fact that this individual also suffered from otitis media, suggests that bacterial meningitis may have been a sequela of this disease. A differential diagnosis of hyperostosis frontalis interna was considered but rejected, as this disorder is characterised by bilateral and "knobby" lesions on the endocranial surface, which are more prevalent among post-menopausal females (Mulhern *et al*. 2006:482).

Figure 7.10: Left - Adult male from Belas Knap long barrow (# 6) with endocranial plaques of new bone (red arrows), consistent with inflammation due to meningitis. Right – detail.

7.3: Viral Infection

7.3.1 Poliomyelitis

Poliomyelitis, or infantile paralysis, is a viral infection caused by an enterovirus within the *Picornaviridae* family, which is spread person to person via the faecal-oral route

(Nathanson and Kew 2010: 1213). Before the introduction of effective vaccines developed by Salk and Sabin in the 1950s, this disease was the most frequent cause of paralysis in children, and to a lesser extent, in adults (Salter 1999: 317). The first wave of immunisation in America saw a decrease in new cases from 58,000 to 5600 in one year, which decreased to only 161 by 1961 (Mehndiratta *et al*. 2014: 223). The WHO are dedicated to eradicate cases of poliovirus through a global vaccination programme, and the year ending 2013 saw only 416 cases reported globally, but the disease is still endemic in three countries; Afghanistan; Pakistan; and Nigeria, accounting for 35% (160/416) of the total cases. The remaining 65% of cases of poliovirus reported for that year were in countries where polio outbreaks where caused by importation from the endemic countries (Table 7.2) (Moturi *et al*. 2014: 469).

Table 7.2: Cases of endemic poliovirus and outbreaks in the year 2013 (Data: Moturi *et al* 2014: 469).

With Endemic Polio	# of Cases
Afghanistan	14
Nigeria	53
Pakistan	93
With Polio Outbreaks	
Cameroon	4
Somalia	194
Syria	35
Ethiopia	9
Kenya	14
Total	416
Total Endemic	160
Total in Outbreak	256

The poliovirus, of which there are three serotypes, enters the human body via the gastrointestinal tract, where it multiplies in the mucosa before being assimilated into the bloodstream via the lymph nodes, causing a transient viremia (Racaniello 2006: 10). The virus may pass out of the body in the faeces within three to five days, with only mild symptoms of gastroenteritis, respiratory infection, or a flu-like illness (Mehndiratta *et al.* 2014: 225). However, in 1% - 2% of infected individuals, the virus sustains a period of replication in the extraneural tissues, such as skeletal muscle and brown fat, facilitating entry into the central nervous system (Racaniello 2006: 10-11).

The anterior horn cells of the spinal cord and brain stem become severley damaged, or destroyed, resulting in permanent limb paralysis (Mehndiratta *et al*. 2014: 225).

Poliomyelitis can be recognised in skeletal human remains. If the disease was contracted during childhood, the affected limb or limbs will exhibit more gracile and shorter long bones, due to interrupted growth and disuse atrophy, but if the disease was contracted during adulthood, the long bones of the affected limb will be of similar length to the unaffected limb, but will be markedly more gracile due to paralysis of the muscles (Waldron 2009: 109). Coxa valga (an increase in the angle of the femoral neck) may be evident if the lower limb is involved, and osteoporosis may be exhibited in the affected limbs due to disuse atrophy, together with pathological fractures caused by osteopenia, or low bone density (Aufderheide and Rodríguez-Martin 2011: 212). Additionally, spinal scoliosis, foot deformities and hip dysplasia are commonly associated with poliomyelitis (Novak *et al*. 2014: 29).

One individual in the current study may have suffered from poliomyelitis, giving a CPR of 0.3%. The adult male, aged between 45 and 49 years at death (the topography of the auricular surface was considered to be Phase 6, based on the ageing method by Lovejoy *et al.* 1985) was excavated from Hazleton North long barrow (Individual D). Although this individual was only 13.9% complete, based on the Zonation Method by Knüsel and Outram (2004), there are some indicators that he may have suffered from the disease.

The skeleton is represented by left and right humeri; left and right radii, left and right ulnae; left and right femora; left and right clavicles; the sacrum; and left os coxae. The right forearm is far more gracile than the left, and in fact, has no interosseous crest on either the radius or ulna, making the opposing aspects of the bones smooth and without definition (Figure 7.11A and 7.11C). This indicates that the interosseous membrane which connects the two bones, and houses the flexor and extensor muscles, had suffered disuse atrophy, possibly due to paralysis. This structure is essential for transmitting the load from the elbow to the wrist, transfers the load from the radius to the ulna, maintains forearm stability, and helps maintain the stability of the distal radio-ulnar joint (Matthias and Wright 2016: 189).

It is difficult to assess whether the right forearm is shorter than the left, as the right ulna is missing its distal end, but the measurement would not be very significant in any case (Table 7.3). The left femur is slightly longer than the right, and the left clavicle is longer than the right but the measurements are not significant. Furthermore, this individual suffered two fractures to the affected forearm. The right ulna has a well-healed parry fracture to the distal shaft, with evidence of a well-healed callus (Figure 7.11 A and B, and also featured in Figure 10.15, Chapter 10). The right radius has a Colles' fracture to the distal end of the bone, which is well-healed but angled in an exaggerated inferior direction on the lateral side (Figure 7.11A). The fractures to the affected limb may have been caused by the lack of density of the bones, due to disuse through paralysis. This individual is also considered to have suffered from spinal scoliosis, although no vertebrae were extant. Evidence for the condition is exhibited on the sacrum, which has unilateral and unsymmetrical sacralisation of the fifith lumbar vertebra (Chapter 11). However, it is possible that curvature of the spine may be more related to this congenital defect, rather than poliomyelitis.

It is unfortunate that this individual is so incomplete, as a comparison of the right and left tibiae and fibulae, and an examination of the foot bones may have helped strengthen the diagnosis of poliomyelitis for this individual. However, the presence of an atrophied right forearm and differences in the length of the femora, together with evidence of scoliosis in this individual, may suggest a diagnosis of poliomyelitis. It may be possible to extract DNA from the bones of this skeleton to detect the genome for poliomyelitis, if it is indeed present (Brown *et al*. 2003: 8973; Sadayo *et al*. 2004: 384). Atrophy to the limbs may have other aetiologies, such as Erb's palsy, which affects the upper limb (Brothwell and Browne 2002: 8). However, this condition is often caused by birth trauma, and would therefore affect the longitudinal length of the bones, which is not significant in this case. Trauma should also be considered as a possible cause to the atrophy of the upper limb, as should a cerebrovascular accident (stroke), or indeed Herpes zoster (shingles).

Table 7.3: Complete long bone lengths (mm) of Individual D from Hazleton North long barrow.

Element	Left (length mm)	Right (length mm)
Humerus	331	342
Radius	261	261
Ulna	278	250 (incomplete)
Femur	461	455
Clavicle	162	156

Figure 7.11: A – Forearms of Individual D from Hazleton North long barrow, with disuse atrophy of right forearm. Note the lack of interosseous crests on the bones (red arrow), the parry fracture on the ulna (red circle), and Colles' fracture on the radius (black arrow). B – Detail of parry fracture to right ulna. C. Comparison of left and right ulnae to illustrate how gracile the right element is.

7.4: Summary

The results of this chapter have outlined that ten individuals, representing 3.3% of the population (10/305), exhibited evidence of infection in the Neolithic period in this study. However, there was a surprising lack of evidence for non-specific infections, with only one case of osteomyelitis, giving a CPR of 0.3% and a TPR of 0.9%. Four bones (two fibulae, a tibia, and a femur) exhibited periosteal new bone formation, which probably only represent two individuals, giving a CPR of 0.7% and a TPR of 1.9%, 0.8%, and 0.9% respectively. The reasons for this are unclear, but may be due to the fragmented assemblages which may, in the case of periostosis, caused the delicate woven bone to become detached from the cortical surfaces of any affected bones.

The six cases of otitis media gave a CPR of 2% which is quite significant and may be due to the fact that sedentism increases the exposure to smoke from open fires within the homestead, which have a correlation with increased susceptibility to ear infections (MacIntyre *et al.* 2011: 86). More females than males were affected by the condition, with two females affected in both the left and right ear. The TPR for the left temporal was 6.3%, which affected females only. The TPR for the right temporal was 5.6% for males and 10.3% for females. The possible case of meningitis, giving a CPR of 0.3% and a TPR of 1.8%, was found in an individual who also suffered from otitis media, and was likely a complication of the former. The individual possibly suffering from poliomyelitis, giving a CPR of 0.3%, likely survived for a prolonged time with a paralysed upper right limb, which may provide insights into care within the communities in this period, as this individual would have been limited in the amount of labour he would have been able to contribute.

Chapter 8: Joint Disease

8.1: Introduction

Joint disease is one of the most common and easily recognised categories of pathology found on human skeletal remains, and together with dental disease, forms approximately two-thirds of all pathological lesions recorded (Waldron 2012: 513). There are six types of joint in the human body, detailed in Table 8.1.

Table 8.1: Types of joints in the human body (after Waldron 2009: 25).

Joint	Character	Example
Suture	Bone joined by connective tissue, largely immobile.	Skull
Syndesmosis	Fibrous joint where articulating bones are joined by ligaments. Minimal movement allowed.	Distal radio-ulnar joint Distal tibio-fibular joint
Gomphosis	Fibrous articulation between teeth and alveolus.	Teeth
Symphysis	Bones joined by fibrocartilage or fibrous connective tissue. Limited movement allowed.	Pubic symphysis Intervertebral discs Sterno-manubrial joint
Synchondrosis	Temporary joints composed of hyaline cartilage in growing skeleton, eventually replaced by bone.	Growth plates Neurocental joint
Synovial	An articulation between two bones, encapsulated in synovial capsule. Full movement allowed.	Large and small joints of the extremities. Facet joints of spine. Costovertebral and costotransverse joints. Sternoclavicular joint.

Synovial joints may be broken down into six types: hinge joint, which bends in only one plane, such as the ulno-humeral joint; pivot joint, which allows rotational movement in one plane, such as the proximal radio-ulnar joint; condyloid, a concave joint allowing biaxial movement (flexion, extension, abduction, adduction, and circumduction), such as the joint between the radius and the scaphoid; saddle, a convex joint which allows biaxial movement, such as the joint between the trapezium and the first metacarpal; ball and socket, a joint which allows multi-axial movement, such as the gleno-humeral and acetabulo-femoral joints; and plane, a gliding joint that allows movement over opposing surfaces, such as the acromio-clavicular joint, and the apophyseal joints of the vertebrae (Byers 2010: 54; Hansen 2010: 9).

Synovial joints are characterised by the articulation between skeletal elements which are separated by a narrow articular cavity, which is lined by the synovial membrane, and totally enclosed by a fibrous membrane (Drake *et al*. 2010: 20). The synovial membrane secretes synovial fluid into the capsule, providing lubrication for the joint surfaces, nutrition for the chondrocytes, and acts as a filtering system for debris and micro-organisms produced by wear and tear of the joint surfaces (Waldron 2009: 25-6). Hyaline cartilage covers the articulating surfaces of the opposing bones, providing a gliding movement without friction, which acts as a shock absorber for the subchondral bone (Salter 1999: 18). The cartilage has no blood or lymph supply and is not innervated, therefore severley limiting its ability to heal or regenerate, eventually leading to progressive osteoarthritis (Drake *et al.* 2010: 21; Salter 1999: 18).

Joint diseases may be recognised in human skeletal material that has undergone disruption of the cartilage that overlies joint surfaces, allowing the normal smooth contours and well-defined margins to alter (Rogers *et al*. 1987: 179). The way in which the skeleton reacts to insult is twofold – either by new bone formation (proliferation), or resorption of bone in the form of erosive lesions (destruction/erosion) (Rogers *et al.* 1987: 180). The proliferation of bone may be apparent on the margins or on the surface of the joint in the form of osteophytes (discussed in more detail in the next section), and are not usually accompanied by inflammation *in vivo,* and these changes in morphology are most characteristic of osteoarthritis (Rogers and Waldron 1995: 11; Waldron 2012: 513). Rogers *et al.* (1987: 181) include Diffuse Idiopathic Skeletal Hyperostosis (DISH) under the proliferative joint diseases, as the most striking characteristic of this disease is the fusion of extra-spinal enthuses and ligaments running down the spine. However, Aufderheide and Rodríguez-Martin (2011: 97) contend that DISH is not a true arthropathy, as neither cartilaginous tissue nor synovium are involved in the disease.

Erosion, or destruction of bone, can produce lesions on the margins of joints, in the centre of joints, or outside of the joint capsule, in which the cortical bone is lost, exposing the trabeculae beneath (Rogers and Waldron 1995: 12). Erosive joint disease includes erosive osteoarthritis, rheumatoid arthritis, gout, ankylosing spondylitis, psoriatic arthropathy, reactive arthropathy, and enteropathic arthropathy (Waldron 2009: 47). Unlike proliferative arthropathies, those in the erosive category have a major inflammatory component (Waldron 2012: 521). However, erosive osteoarthritis is neither solely proliferative nor erosive but has characteristics of both types (Waldron 2012: 522). Erosive lesions on dry skeletal material may be recognised by the presence of: subchondral destruction of bone; exposure of trabecular bone; undercut edges; scalloped defects on the bone; and periosteal reaction (Rogers *et al.* 1987: 182-3).

8.2. Osteoarthritis

Osteoarthritis is a disease which only affects the synovial joints and is commonly reported in palaeopathological literature, and should not be confused with degenerative joint disease, which involves the natural degeneration of the joints with advancing age (Section 8.6.1). Osteoarthritis involves the breakdown of the articular cartilage and is characterised by the formation of marginal osteophytes; reactive subchondral bone, in the form of eburnation, sclerosis and cysts; pitting on joint surfaces; and alterations to joint contours (Rogers *et al.* 1987: 185), and these diagnostic indicators are discussed below in more detail. The way in which the cartilage tissue fails is threefold: micro-cracks appear initially and the cartilage cells (chondrocytes) proliferate, followed by a gradual deepening of the micro-cracks into fissures, which allows the cartilage to fragment into the articular space, thereby exposing the subchondral bone; microcysts, or erosions, develop on the exposed bone, accompanied by inflammation of the synovium, sclerosis of the exposed bone, and osteophyte formation, which may represent the body's attempt at stabilisation and repair of the joint (Burt *et al*. 2013: 5; Waldron 2009: 27).

Osteoarthritis may be classified as either primary or secondary, the latter category develops as the result of injury, congenital defect, or disease of the affected joint (Salter 1999: 258). The following discussion concerns primary osteoarthritis, as no individuals in this study were considered to have suffered from secondary osteoarthritis. The aetiology of the disease is unclear, but several factors have been linked to the pathogenesis of the disease such as: age (virtually all individuals over 65 years of age will have a least one osteoarthritic joint); genetic disposition; sex (females are more susceptible than males); race; obesity; trauma; and activity (unmoveable joints do not suffer from osteoarthritis) (Rogers and Waldron 1995: 32; Waldron 2009: 28; Solomon 2001: 1410). Any synovial joint may be affected by osteoarthritis, but the most common joints affected are the first carpo-metacarpal joint; the apophyseal joints of the cervical and lumbar vertebrae; the first metatarsophalangeal joint; the acromioclavicular joint; the knee; and the hip (Figure 8.1) (Rogers and Waldron 1995: 32).

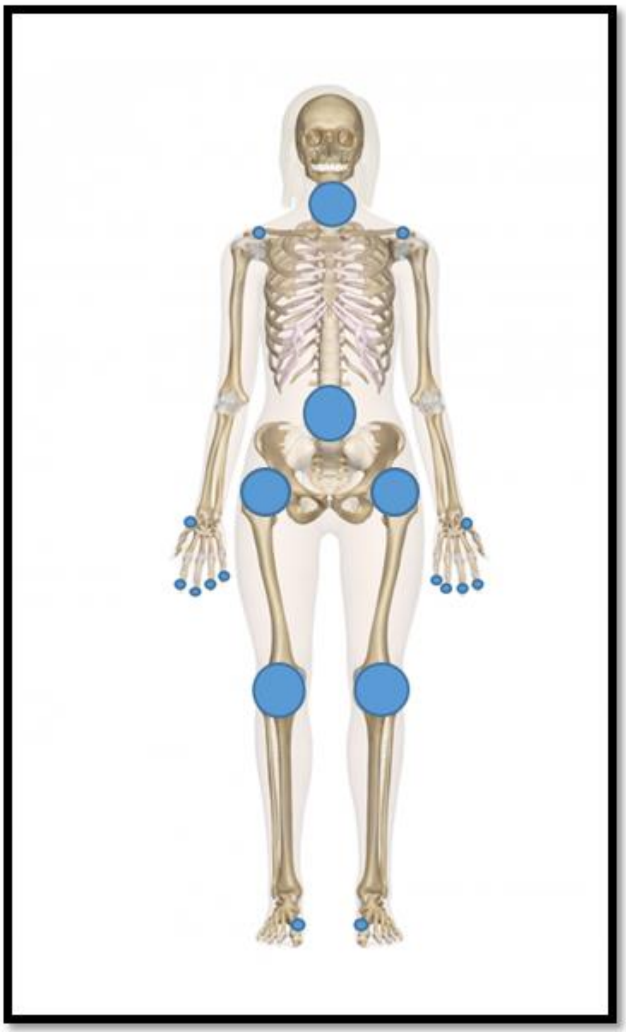


Figure 8.1: The most common joints (circled in blue) affected by osteoarthritis in skeletal samples (after Rogers and Waldron 1995).

The study of skeletal material has greatly advanced the understanding and patterning of osteoarthritis, as palaeopathologists have the opportunity to examine and evaluate all of the joints on the skeleton, a process seldom undertaken in clinical assessments, and which can reveal sites that were previously unrecognised as affected by osteoarthritis, such as the joint between the first and second cervical vertebrae, where the odontoid process articulates with the atlas (Figure 8.2) (Rogers and Waldron 1995: 33). Diagnosis of osteoarthritis at this joint would be extremely unlikely in a living patient, as the joint is obscured by both bone and soft tissues, which may not be penetrated by radiographs (Rogers and Waldron 1995: 330; Rogers *et al*. 1987: 183).

Figure 8.2: Second and third fused vertebrae from Nympsfield long barrow, with eburnation on the odontoid process.

The features of osteoarthritis that may be seen on radiographs and which are used to diagnose the disease clinically are narrowing of the joint space, caused by loss of cartilage tissue; osteophyte formation; an alteration in the shape of the joint; bone volume reduction; and the formation of cysts and sclerotic subchondral bone (Burt *et al*. 2013: 6). In addition, a patient may complain of pain in the affected joint which may be accompanied by swelling and restriction of movement. However, the presence of a painful joint may not show any signs of osteoarthritis radiographically, and conversely, joints that have all the radiographic signs of the disease may not be accompanied by any pain whatsoever (Watt 2000:174).

The operational diagnosis for osteoarthritis in skeletal human remains is the presence of eburnation on the joint, *or* at least two of the following: marginal osteophytes; new bone formation on the joint surface; pitting on the joint surface; joint contour change (Waldron 2009: 34).

Eburnation

Eburnation is pathognomonic for osteoarthritis, and is readily identified in archaeological material (Figure 8.2 and 8.3), as it is characterised by a hard, shiny surface, which resembles a billiard ball (Waldron 2012: 514). Eburnation is caused by bare bone rubbing against the bare bone of the reciprocal joint, where the cartilaginous tissue has been lost (Rogers and Waldron 1995: 13).

Figure 8.3: A - Right lunate with eburnation (arrowed) and pitting of the articular surface with the hamate from Hazleton North long barrow (# 6277). B – Detail.

Osteophytes

Osteophytes are spicules of new bone that arise around the margins of joints where the synovial membrane is continuous with the articular cartilage, and are very common in archaeological assemblages, due the fact that they are not only an indicator of osteoarthritis, but are present in most individuals over 50 years of age as a sign of wear and tear of well-used joints (Rogers and Waldron 1995: 20-21). Enthesophytes, which are the vertebral equivalent to osteophytes, develop on the margins, or annulus fibrosis (Figure 8.4), when the intervertebral disc has degenerated sufficiently to allow contact between bodies, stimulating the periosteum to form new bone (Aufderheide and Rodríguez-Martin 2011: 96). Osteophytes develop most commonly at the acetabulo-femoral joint, the knee (patella-femoral and tibio-femoral joints), the distal interphalangeal joints, around the vertebral bodies, the apophyseal joints of the vertebrae and on the odontoid process (Waldron and Rogers 1995: 20).

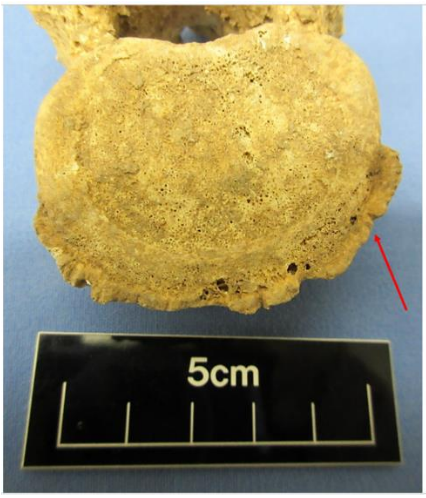


Figure 8.4: Lumbar vertebra from West Kennet long barrow (EU.1.5.140) exhibiting marginal enthesophytes.

New Bone Formation

As with the formation of osteophytes, new bone will be laid down on the joint surface as a result of inflammation to the periosteum (Figure 8.5) (Waldron 2009: 33). This phenomenon on its own is not pathognomonic for osteoarthritis, but in conjunction with the other characteristics discussed here, may be used to give a differential diagnosis of the disease.

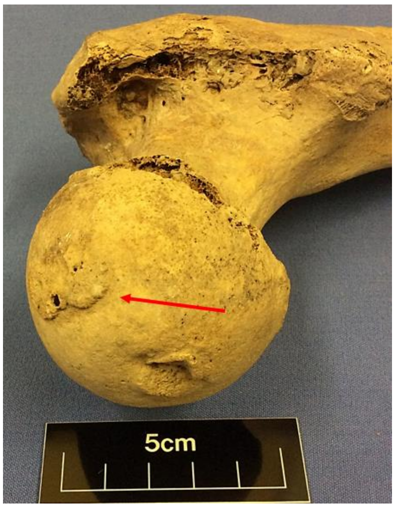


Figure 8.5: Right femur from Handley 27 barrow with new bone formation on the head, superior to the fovea.

Pitting/Porosity

The presence of porosity on a joint surface is not an indicator of osteoarthritis by itself, but it is invariably associated with eburnation on affected joints (Figure 8.3), and is associated with increased blood flow entering subchondral bone following the destruction of cartilaginous tissue (Ortner 1968: 145). Rothschild (1997: 531) has argued that there is no correlation between porosity and osteoarthritis and that this characteristic should not be used to identify the disease. However, subsequent clinical studies have shown that patients diagnosed with osteoarthritis, have a higher rate of porosity on subchondral and cortical bone than those with no sign of bone disease, or those diagnosed with osteoporosis (Li *et al*. 1999: 105; Blain *et al*. 2008: 865).

Joint Contour Change

Change to joint contours is due to the affected subchondral bone remodelling and producing enlarged or flattened joint surfaces (Rogers *et al*. 1987: 182) (Figure 8.6).

Figure 8.6: Left talus from adult female from Hazleton North long barrow (Skeleton F), with flattened calcaneal facet, osteophytes (red arrows) and porosity (yellow arrow).

8.2.1. Osteoarthritis of the Temporo-Mandibular Joint

The Temporo-mandibular joint is divided into two parts – the superior part is placed between a disc of cartilage and the temporal bone, the inferior between the disc and the mandibular condyle (Drake *et al*. 2010: 923). Both portions of the joint may be affected by the disease, causing the usual suite of changes, and the aetiology of the disease is thought to be linked to excessive tooth wear, where the joint has to compensate for altered masticatory movements (Aufderheide and Rodríguez-Martin 2011: 95). Jurmain's (1990: 89) study of prehistoric populations in America revealed that the prevalence for moderate osteoarthritis of the temporo-mandibular joint was 6.1% for the right joint, and 3.7% for the left. A more recent study by Rando and

Waldron (2012) compared the prevalence rates for the disease in four different populations, Medieval and Post-Medieval Londoners, prehistoric south-west Native Americans, and modern American documented populations, using the criteria set out by Waldron (2009:34). These are the presence of eburnation on the joint, *or* at least two of the following: marginal osteophytes; new bone formation on the joint surface; pitting/porosity on the joint surface; joint contour change. Rando and Waldron's study revealed that the modern American examples approximated those of modern clinical studies using the criteria (30.2%), but the prehistoric south-west Native American population had the lowest prevalence rate at 10.6%, and the Medieval and Post – Medieval Londoners had rates of 13.3% and 29.5% respectively (Rando and Waldron 2012: 50).

The analysis of the human remains from 42 sites for the current study revealed that eight individuals (three males, two females, and three unsexed) suffered from osteoarthritis of the temporo-mandibular joint, giving a crude prevalence rate of 2.6% (8/305). The TPR for the separate sides of the joint are given in Table 8.2. In three cases, both the cranium (mandibular fossa) and mandible were affected, in all of the joints. The remaining five individuals were either represented by just a mandible or a cranium, or in the cases of Belas Knap DI and the individual from Kings Playdown, the joint was damaged and unobservable.

Table 8.2: Joints affected by osteoarthritis of the temporo-mandibular joint.

Site	Sex	Age	Mandible (L)	Mandible (R)	M Fossa (L)	M Fossa (R)
Belas Knap DI	F	30-54	Missing	Missing	✓	Unobservable
Belas Knap BII	M	25-35	✓	✓	Missing	Missing
Nympsfield	UND	?	✓	Missing	Missing	Missing
Tilshead Old Ditch	F	48-56	✓	✓	✓	✓
Kings Playdown	M	33-45	✓	✓	Unobservable	Unobservable
Lanhill EU.1.5.104	M	39-56	✓	✓	✓	✓
Hazleton 4788	UND	45+	✓	✓	✓	✓
Hazleton 11456	UND	45+	✓		Missing	Missing
TPR%			8% (7/88)	5.6% (5/89)	8.7% (4/46)	6.4% (3/47)
TPR by sex			M 11% (3/27 F 5.3% (1/19)	M 11% (3/27) F 5.5% (1/18)	M 4.8% (1/21) F 15% (2/13)	M 4.3% (1/23) F 8.3% (1/12)

A male adult from Lanhill long barrow (EU.1.5.104) suffered from osteoarthritis of the temporo-mandibular joint on both opposing bones. The mandibular fossa on the left has more osteoarthritic changes than the right, and is porous, has marginal lipping, and contour change (Figure 8.7). The mandible is affected on both sides – the right condyle has contour change in the form of a flattened articular surface, and also has marginal lipping (Figure 8.8). The left condyle is affected by porosity, marginal lipping, and contour change. It is evident that this individual exhibited ante-mortem tooth loss in the mandible, so it is unclear whether the osteoarthritis was related to severe dental attrition in this case.

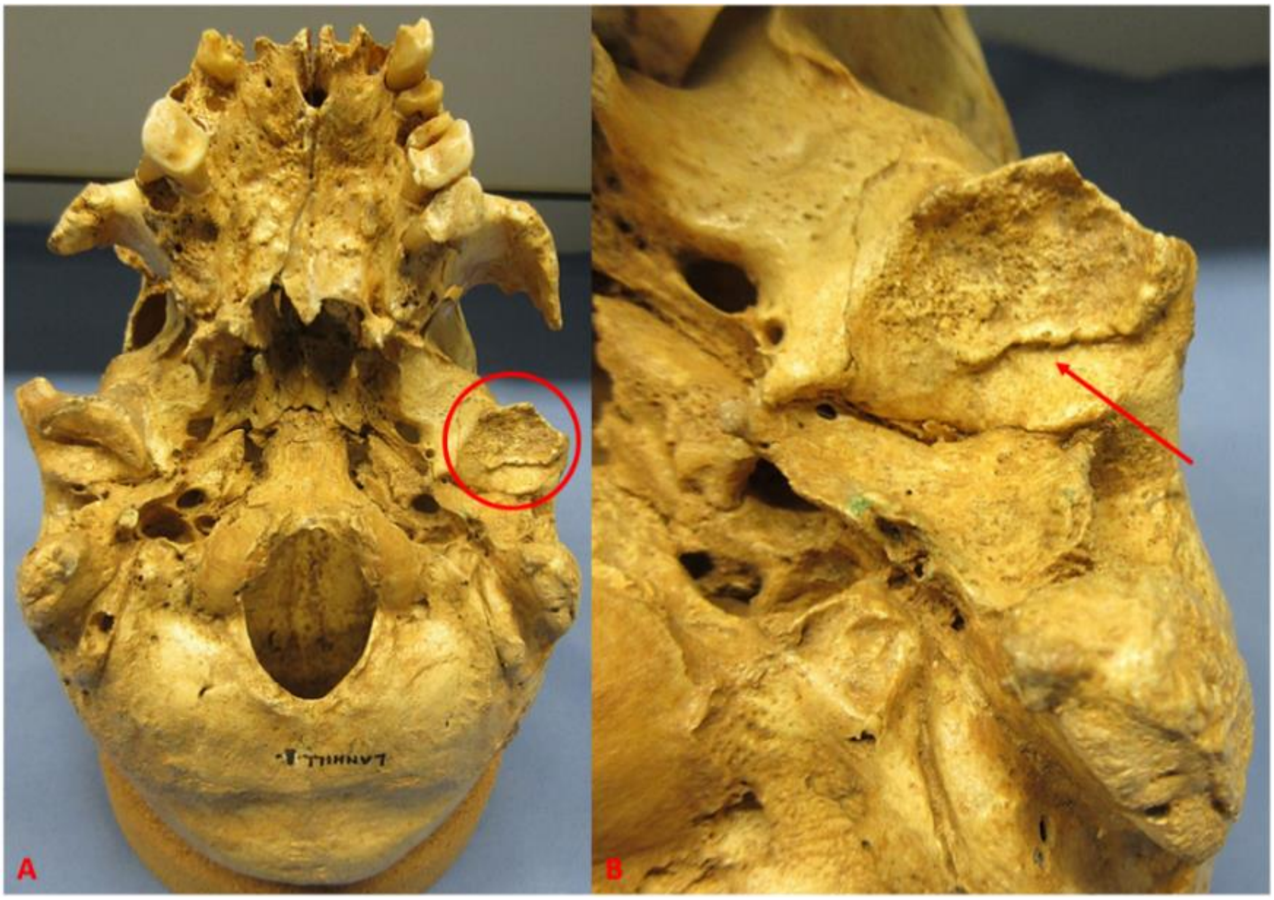


Figure 8.7: A - Cranium of adult male from Lanhill long barrow (EU.1.5.104), exhibiting osteoarthritis of the temporo-mandibular joints. Contour change and lipping in the right mandibular fossa, and porosity, marginal lipping, and contour change on the left side (red circle). B – Detail.

Figure 8.8: A - Mandible from Lanhill long barrow (EU.1.5.104) with osteoarthritis of the temporo-mandibular joints. B - Right condyle has contour change in the form of a flattened articular surface and marginal lipping. C - Left condyle is affected by porosity, marginal lipping, and contour change.

8.2.2 Osteoarthritis of the Sterno-clavicular Joint

The sterno-clavicular joint is commonly affected by osteoarthritis and examination of post-mortem reports have revealed that 50% of those aged over 60 will have the condition (Robinson *et al*. 2008: 689). Males are more affected than females, and the medial end of the clavicle is more affected by the disease than the clavicular notch of the manubrium (Resnick 2002c: 1324).

Three medial clavicles and the clavicular notches of two manubriums were affected by osteoarthritis of the sterno-clavicular joint in the current study, and all of the bones came from Hazleton North long barrow. Two of the clavicles, a left and a right, belong to Skeleton A, a mature adult male, aged between 23 and 57 years. The other clavicle (right side) belongs to a mature female, Skeleton F, aged at least 40 years, and it possible that one of the manubriums (# 5771) also belongs to this individual, as it was excavated from the same context and Skeleton F was not assigned its own manubrium. Furthermore, it cannot be ruled out that the other manubrium (# 6570) belongs to Skeleton A, as this element was not listed in the skeletal inventory for this individual. Therefore the number of sterno-clavicular joints affected by osteoarthritis in this study is three, probably belonging to only two individuals. The crude prevalence rate for this condition is therefore 0.6% (2/305). The TPR for the left clavicle is 1.9% (1/54), and 3.6% for the right side (2/55). When the TPR is adjusted for sex, the rate for left clavicles for males is 10% (1/10 male clavicles), and 6.25% for the right (1/16).

The TPR for females is 5.9% (1/17 right female clavicles). The TPR for the manubriums is 5.4% (2/37), and when adjusted are 10% (1/10) for males and 100% for females (1/1). Incidentally, all of the clavicles also have osteoarthritic changes to the acromio-clavicular joint, and Figure 8.12 features this joint (Skeleton F). The clavicles all show extensive porosity, contour change and marginal osteophytes (Figure 8.9A), as do both of the manubriums on both facets (Figure 8.9B).

Figure 8.9: A - Right clavicle from Hazleton North long barrow (Skeleton F), with osteoarthritic changes (porosity, contour change, and marginal osteophytes) to the sterno-clavicular joint (left). B – Manubrium, possibly from the same individual with osteoarthritic changes (porosity, contour change, and marginal osteophytes), right.

8.2.3. Osteoarthritis of the Spine

Osteoarthritis of the spine occurs mainly on the paired apophyseal joints of the vertebrae, in particular, those of the cervical and lumbar vertebrae, reflecting the range of movement possible in these types of vertebrae (Resnick 2002d: 1405). In modern populations, spinal osteoarthritis affects 60% of females and 80% of males by the age of 60, increasing to 100% by the age of 90 (Schmorl and Junghanns 1971: 186-7). In addition to the osteoarthritic changes on the vertebral facets, enthesophytes may form on the superior and inferior margins of the vertebral bodies, and osteophytes can form on the joint between the atlas and odontoid peg of the axis (Rogers and Waldron 1995: 33). Osteoarthritis of the cervical spine can lead to neck and arm pain and the disease is characterised by low back pain, stiffness and sciatica in the lumbar region (Salter 1999: 285).

Only five out of the 42 sites analysed had evidence of osteoarthritis of the spine, in the form of porosity, eburnation and contour change of the apophyseal joints, representing at least seven individuals, giving a CPR of 2.3% (7/305) (Figure 8. 10) (Table 8.3). Signs of osteoarthritis in the form of eburnation on the joint between the atlas and odontoid process, and osteophytes on the odontoid process were found at five sites, representing at least eight individuals, giving a CPR of 2.6% (8/305) (Figure 8.2) (Table 8.4). In addition, the disease was present at four sites, in the form of marginal enthesophytes to the vertebral bodies (Figure 8.11) (Table 8.5), giving a crude prevalence rate of 1.3% (4/305).

Table 8.3: Spinal osteoarthritis on the apophyseal joints of the vertebrae.

Site	Sex	Age	Cervical	Thoracic	Lumbar
Hazleton North (Skeleton A)	M	23-57	2	2	0
Hazleton North (Skeleton F)	F	40+	4	0	0
Hazleton North (Skeleton 1)	M	40-45	0	1	0
Lanhill EU.1.5.104	M	39-56	4	10	0
West Kennet (Skeleton EU.1.5.140)	M	23-57	0	2	0
West Kennet (SE Chamber)	UND	?	0	1	1
West Kennet (NW Chamber)	UND	?	1	0	0
Luckington	UND	?	0	1	0
Rodmarton	UND	?	2	1	0

Table 8.4: Osteoarthritis of the first and second cervical vertebrae.

Site	Sex	Odontoid Process Eburnation	Atlas Eburnation (dens facet)	Osteophytes Odontoid Process
Hazleton North (Skeleton 2)	M?	✓	✓	
Hazleton North # 14338	UND	✓	✓	
Hazleton North # 9906	UND		✓	
Hazleton North # 7859	UND	✓		
Lanhill EU.1.5.104	M	✓	✓	✓
Lanhill EU.1.5.105	F		✓	
Millbarrow# 5719	UND			✓
Hetty Pegler's Tump (Uley) # 78/1965	UND	✓	✓	✓
Nympsfield # 2020	UND	✓		

Table 8.5: Individuals with marginal enthesophytes on the vertebral bodies.

SITE	Sex	Cervical Vertebrae	Thoracic Vertebrae	Lumbar Vertebrae
Hazleton North (Skeleton A)	M	0	2	0
Hazleton North # 5892	UND	0	0	4
Broadsands # A3039.1	UND	0	0	1
Luckington # GC/A/1	UND	1	0	3
Lanhill EU.1.5.104	M	0	0	1

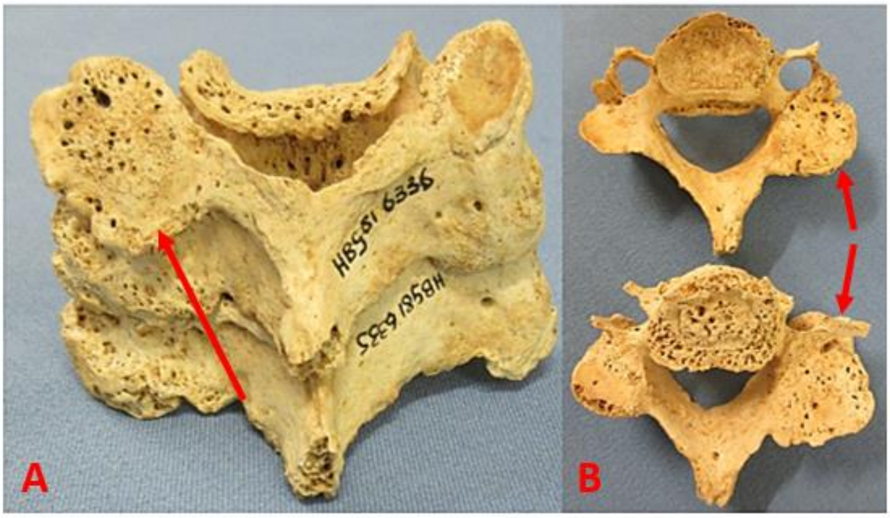


Figure 8.10: A - Osteoarthritis of the apophyseal joints of two cervical vertebrae from Hazleton North (Skeleton A), superior facets. B - Inferior facets.

Figure 8.11: Marginal enthesophytes on a lumbar vertebra from Hazleton North long barrow (# 5892).

8.2.4. Osteoarthritis of the Shoulder

Osteoarthritis of the gleno-humeral joint is rare, and where it does occur, the cause may be ascribed to trauma (Resnick 2002c: 1313). Osteoarthritis of the acromio-clavicular joint is common though, and is found in most elderly individuals (Waldron 2009: 35). Both the glenoid fossa and the humeral head may show osteoarthritic change, and are similar to those seen in the acetabulo-femoral joint, but with less severity, due to the fact that the shoulder joint is not weight-bearing (Resnick 2002c: 1313).

Three individuals from Hazleton North long barrow suffered from osteoarthritis of the shoulder, giving a crude prevalence rate of 1% (3/305) (Table 8.6). Skeleton 1, an adult male, (Figure 8.12A) has porosity and lipping to the right glenoid fossa and an unassigned left scapula (# 8497) has marginal osteophytes, contour change and porosity to the glenoid fossa, giving a TPR of 1.9% for the left (1/52) and 2.3% for the right (1/43), with a figure of 5.6% when adjusted for sex (1/18 right scapulae). Five clavicles, a right from Skeleton 1, a left and a right from Skeleton F, and a left and right from Skeleton A (a mature male) exhibit marked porosity, contour change and marginal osteophytes to the lateral end, at the acromio-clavicular joint (Figure 8.16B), giving a TPR of 3.3% for the left (2/61), and 4.9% (3/61) for the right. When the TPR is adjusted for sex, the left clavicle is 5.3% (1/19) for females, and 9.1% (1/11) for males, and the right clavicle is 11.8% for males (2/17) and 6.25% for females (1/16). Only Skeleton A had corresponding pathology in the opposing acromion of the scapula, giving a TPR of 2.3% (1/44), and an adjusted figure for sex of 9.1% (1/11).

Table 8.6: Individuals from Hazleton North long barrow with osteoarthritis of the shoulder.

Individual	Clavicle	Glenoid Fossa	Acromion
Skeleton A	Left & Right		Left
Skeleton 1	Right	Right	
Skeleton F	Left & Right		
# 8497		Left	

Figure 8.12: A – Left scapula from Skeleton 1, Hazleton North long barrow, with flattening of the glenoid fossa, marginal osteophytes and porosity. B – Right clavicle from Skeleton F, Hazleton North long barrow, with osteoarthritis to the acromio-clavicular joint (porosity, contour change, and marginal osteophytes).

8.2.5. Osteoarthritis of the Elbow

Osteoarthritis of the elbow is reported as rare in the literature (Resnick 2002c: 1313), except for secondary osteoarthritis, following trauma. However, Ortner (1968: 144) reports a prevalence rate of 18% and 5% for osteoarthritis of the elbow in Alaskan Eskimos and Peruvian Indians respectively, and Debono *et al.* (2004: 399) found that over 25% of the individuals from a French necropolis had the disease. Furthermore, Jurmain's (1990: 89) study of prehistoric Californian populations found that the disease was moderately evident in 4.6% of the individuals for the left elbow, and 4.3% for the right. There are three compartments for the elbow – the ulnar-humeral joint, the radio-humeral joint, and the proximal radio-ulnar joint, all of which may be affected by the disease (Ortner and Putschar 1981: 425).

Four individuals from the current study suffered from moderate osteoarthritis of the elbow, giving a crude prevalence rate of 1.3% (4/305). In all cases, the affected element was the proximal ulna, and six ulnae were affected in total (Table 8. 7). An adult male from Lanhill long barrow (EU.1.5.106) and an un-sexed adult from

Rodmarton long barrow exhibited new bone formation, eburnation and porosity in the trochlear notch of the left and right ulna respectively. A possible adult female from Wor Barrow (Skeleton 5) also had moderate osteoarthritis of the elbow in both ulnae, which was exhibited in new bone formation, eburnation and porosity in the trochlear notches. An adult male from West Kennet long barrow (EU.1.5.140) also exhibited these characteristics of the disease in both ulnae, but also had lipping to the radial notch on both bones (Figure 8.13). The TPR is therefore 5.2% for the left ulna (3/58) and 4.1% for the right ulna (3/74). The TPR adjusted for sex is given in Table 8.7.

The ulna from Rodmarton was a disarticulated element, with no accompanying bones. The two individuals from Lanhill long barrow and Wor barrow both had the corresponding humeri, and the adult from West Kennet had the right humerus, but these bones did not show any sign of the disease, perhaps indicating that the disease was in the early stages.

Table 8.7: Individuals from this study with osteoarthritis of the elbow.

Site	Side	Age	Sex	New Bone	Porosity	eburnation	Lipping	TPR %
Lanhill (EU.1.5.106)	Left	25-35	M	✓	✓	✓		22% (2/9)
West Kennet (EU.1.5.140)	Left	23-57	M	✓	✓	✓	✓	
West Kennet (EU.1.5.140)	Right	23-57	M	✓	✓	✓	✓	6.3% (1/16)
Rodmarton (unmarked)	Right	?	?	✓	✓	✓		
Wor Barrow (Skeleton 5)	Left	33-45	F?	✓	✓	✓		6.7% (1/15)
Wor Barrow (Skeleton 5)	Right	33-45	F?	✓	✓	✓		33% (1/3)

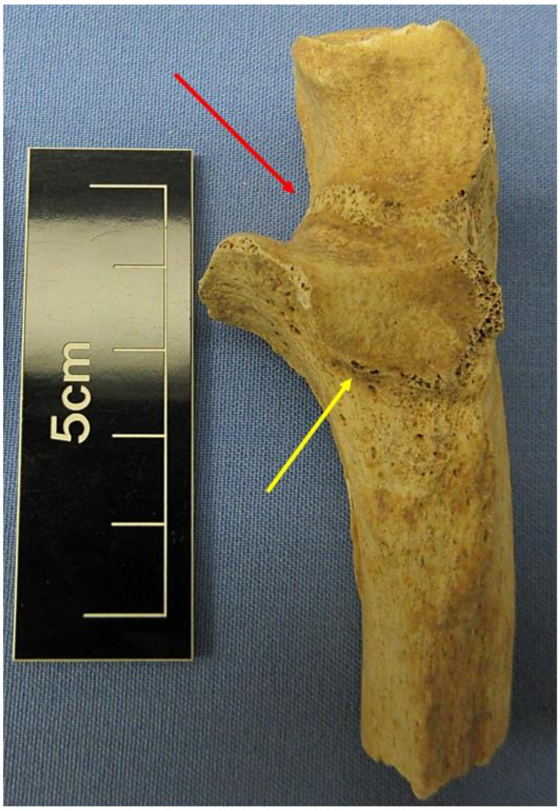


Figure 8.13: Left proximal ulna from West Kennet long barrow (EU.1.5.140) with eburnation, new bone formation and porosity to the trochlear notch (red arrow), and lipping to the radial notch (yellow arrow).

8.2.6. Osteoarthritis of the Wrist

Primary osteoarthritis of the wrist is relatively rare but the condition is more commonly experienced secondary to fracture or disease (Waldron 2009: 37). Osteoarthritis of the wrist affects the radiocarpal joint, where the radius articulates with the lunate and scaphoid; and the joints where carpals articulate with another (Brewer and Storey 2016: 145).

At least two individuals suffered from osteoarthritis of the wrist in the current study, and all of the affected elements were excavated from Hazleton North long barrow. Skeleton A, a mature male, exhibited osteoarthritic changes to the left distal radius, in the form of new bone formation, porosity, and marginal lipping to the facets that articulate with the lunate and scaphoid (Figure 8.14A). Six carpal bones, a left and right trapezium (# 9831 and # 9233), two right lunates (# 6277 and # 4597), and a left and right scaphoid (# 6479 and # 10093) all had osteoarthritic changes in the form of eburnation, porosity and marginal lipping. Both of the lunates had osteoarthritic changes on the facet with the hamate. The left scaphoid had signs of the disease on the facet for the trapezoid, and the right scaphoid had changes on the facet with the trapezium. Both of the trapeziums had osteoarthritic changes in the facets for the wrist and hand: the left trapezium has eburnation, porosity and contour changes on the scaphoid facet and the facet for the first metacarpal (discussed in Section 8.2.7); and the right trapezium has lipping and porosity on the facets with the scaphoid and trapezoid (Figure 8.14B), and eburnation, porosity and lipping on the facet for the first metacarpal (Section 8.2.7).

It is possible that some of the carpals may belong to Skeleton A, therefore only two adults are considered to have osteoarthritis of the wrist, giving a crude prevalence rate of 0.6% (2/305). The TPR for the right lunate is 8.3% (2/24); for the left scaphoid 3.6% (1/28); the right is 4% (1/25); the left trapezium is 5.6% (1/18); and for the right trapezium 6.3% (1/16).

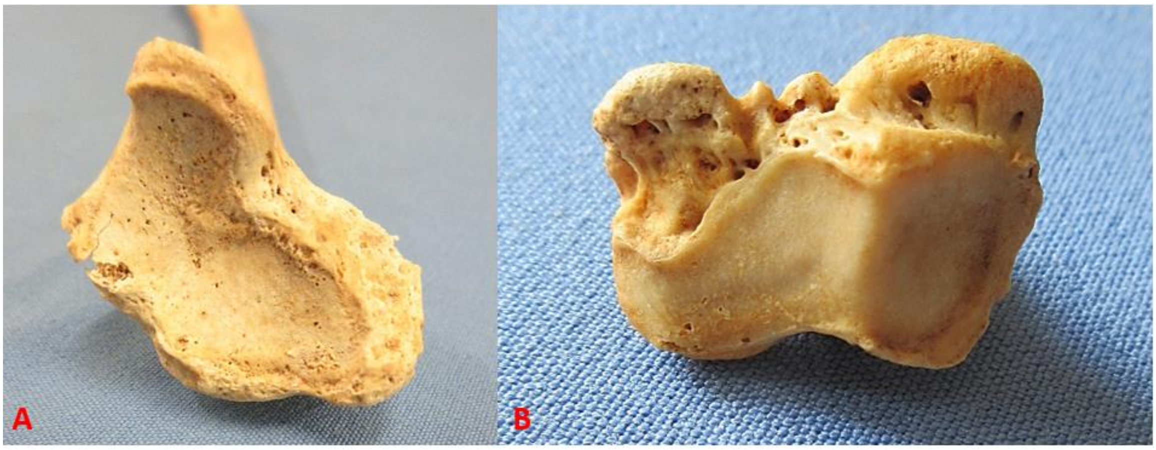


Figure 8.14: A – Left distal radius from Skeleton A (Hazleton North long barrow) with new bone formation, porosity, and marginal lipping on the facets with the lunate and scaphoid. B – Right trapezium (# 9233) with marginal lipping to the facets for the scaphoid and trapezoid.

8.2.7: Osteoarthritis of Hand

In studies of a contemporary American population, osteoarthritis of the hands affects females more than males, especially after 50 years of age (Arden and Cooper 2006: 12). The most affected joints are the trapeziometacarpal joint of the thumb, and the distal and proximal interphalangeal joints (Waldron 2009: 37). Marginal osteophytes that develop on the distal interphalangeal joints are called Heberden's nodes, and those on the proximal interphalangeal joints are called Bouchard's nodes (Ortner 2003: 549).

Five elements from Hazleton North long barrow exhibited signs of osteoarthritis of the hands – two first metacarpals (# 9034, left and # 9833 right), one unsided first distal phalanx (# 6533), and the two trapeziums (# 9831 and # 9233) featured in Section 8.2.6 (a left and right). The metacarpals are a right and a left, therefore all of the bones from this site may be from the same individual. In addition, an un-numbered and un-sided first distal phalanx from Fromefield long barrow, and one un-sided first distal phalanx from Luckington long barrow (# GC/A/P) also exhibit signs of osteoarthritis. In consequence, three individuals from the 42 sites studied suffered from the disease, giving a crude prevalence rate of 1% (3/305) (the TPR for the sided elements are given below). This figure is very low, but unfortunately reflects the fact that the carpals and metacarpals were not retained upon excavation in most sites. Six of the sites studied had skeletons in varying degrees of completeness, but in only two of these (West Kennet and Hazleton North), were some of these elements retained. However, the number of metacarpals examined do not reflect the numbers of individuals interred within the monuments. For instance, the minimum number of individuals represented at West Kennet long barrow is 42, but only 163 metacarpals are extant, representing only 39% (163/420) of the expected number.

The left and right first metacarpals from Hazleton North long barrow exhibit signs of osteoarthritis in the form of marginal osteophytes, porosity, and contour change on the proximal end. In addition, the left first metacarpal (# 9034) also has an area of eburnation on the sellar facet for the trapezium (Figure 8.15A). The TPR for the left first metacarpal is 2.5% (1/40) and 2.2% (1/45) for the right. The distal manual phalanx from Hazleton North long barrow exhibits Heberden's nodes on both the lateral and medial sides of the joint, and porosity to the posterior surface (Figure 8.15B). The two trapeziums also from this site both have eburnation, lipping and porosity on the facets with the first metacarpal. The TPR for the left trapezium is 5.6% (1/18) and 6.3% (1/16) for the right. The remaining two distal phalanges from Fromefield long barrow and Luckington long barrow also have Heberden's nodes on the lateral and medial sides, accompanied by macroporosity on the posterior surface.

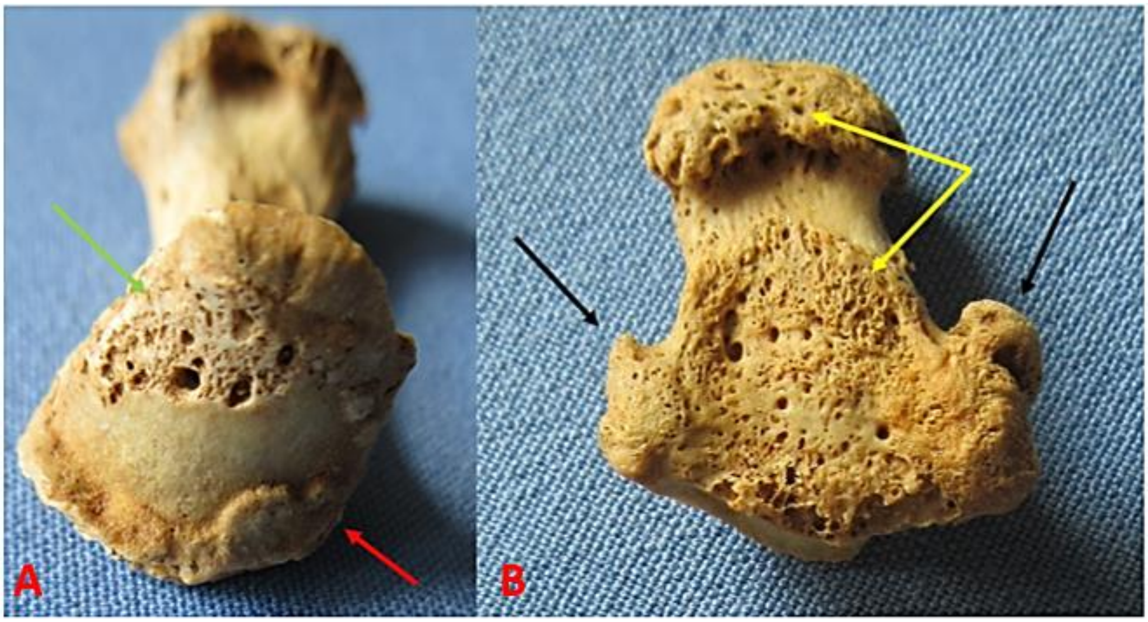


Figure 8.15: A - First left metacarpal from Hazleton North long barrow (# 9034) with eburnation (green arrow). B - Distal manual phalanx from Hazleton North long barrow (# 6533) with Heberden's nodes (black arrow), and porosity (yellow arrows).

8.2.8: Osteoarthritis of the Hip

Osteoarthritis of the hip is very common, both clinically (Dieppe 2008: 224) and in archaeological populations (Rogers and Waldron 1995: 32). The disease is more common in females than males, with a prevalence of 3%, and is commonly unilateral, with the right side affected more than the left (Waldron 1997: 186). In addition, by the age of 60, 50% of the modern population will suffer from osteoarthritis of the hip (Aufderheide and Rodríguez-Martin 2011: 94). In skeletal remains, osteoarthritis of the hip is most noticeable on the femoral head, where new bone can form on the surface and around the fovea, eburnation and erosion may affect the superior or inferior surface, and shape changes, such as mushroom deformity, where the head is flattened and widened, predominate (Waldron 2009: 38; Ortner 203: 548; Rogers and Waldron 1995: 38). Changes to the acetabulum may include marginal osteophytes, eburnation to the acetabular roof, and macroporosity (Resnick 2002c: 1342). Numerous disorders can predispose an individual to osteoarthritis of the hip including congenital hip dislocation, slipped capital femoral epiphysis, and Legg-Calvé-Perthes disease (Salter 1999: 269). Individuals with osteoarthritis of the hip have reported symptoms that include stiffness of the joint and pain, which is worse at night and difficulty in getting out of bed in the morning (Conaghan and Nelson 2012: 33). In addition, patients may encounter restricted participation in everyday activities, such as those that include occupational and leisure activities, which can have an impact on quality of life, leading to loss of esteem, independence and sometimes depression (Conaghan and Nelson 2012: 33).

The analysis of the human skeletal remains from the 42 sites in the current study found that at least four individuals from three sites suffered from osteoarthritis of the hip (Table 8.8) (the left and right os coxae # 4515 and # 8498 could feasibly belong to the same individual). Therefore, the crude prevalence rate of individuals affected is 1.3% (4/305), lower than the rate quoted by Waldron (1997: 186). The reason for this disparity is due to the fact that there were very few sites (only six out of the 42) that produced extant skeletons (representing only 30 individuals) in varying proportions of completeness (see Chapter 5, Table 5.2). The human skeletal remains from the remaining 36 sites were entirely comprised of disarticulated and commingled bones, or just crania and mandibles, thereby severely limiting the number of hip joints available for study.

Table 8.8: Individuals affected by osteoarthritis of the hip in this study.

Site	Age	Sex	Femur	TPR %	Os Coxae	TPR %
Giants Hills (EU.1.5.115)	**24+**	**F**	**Left**	**8.3% (1/12)**	**Left**	**17% (1/6)**
Handley 27	**40-60**	**M**	**Right**	**7.1% (1/14)**		
Hazleton North (Skeleton # 2)	**33-60**	**M?**	**Right**			
Hazleton North (# 4515)	**?**	**?**			**Left**	
Hazleton North (# 8498)	**45+**	**M**			**Right**	**8.3% (1/12)**

Evidence of osteoarthritis of the hip came from an adult female (aged more than 24 years at death) interred within Giant's Hills (Skendleby I) long barrow (EU.1.5.115), in the form of porosity and new bone formation in the left acetabulum, and porosity on the left femoral head. A male adult from Handley 27 long barrow, aged between 40 and 60 years, had new bone formation on the right femoral head (featured in Figure 8.5, Section 8.2), with lipping around the fovea and marginal osteophytes on the margin of the head (the corresponding os coxae was damaged, therefore no evidence of the disease was observed on this bone). Skeleton # 2, a probable male adult from Hazleton North long barrow, aged between 33 and 60 years, exhibited surface osteophytes on the right femoral head and on the fovea rim, accompanied by porosity (Figure 8.16), but the opposing os coxae showed no sign of the disease. A further adult, of unknown sex, from Hazleton North long barrow (# 4515), is represented only by a fragment of the left acetabulum, which exhibited eburnation along the inferior rim. Lastly, a disarticulated right os coxae (# 8498) from a male adult aged approximately 45 years, exhibited marginal osteophytes along the rim of the acetabulum, new bone formation, porosity and eburnation within the acetabulum (Figure 8.17).

The TPR for the left femur is therefore 1.8% (1/56), and 3.4% (2/59) for the right. The TPR for the left os coxae is 5.1% (2/39), and 2.8% (1/36) for the right side. When the figures are adjusted for sex, it is evident that females had a higher prevalence than males for osteoarthritis of the hip: 8.3% (1/12) versus 7.1% (1/14) for the proximal femur, and 17% (1/6) for females and 8.3% (1/12) for males for the ossa coxae.

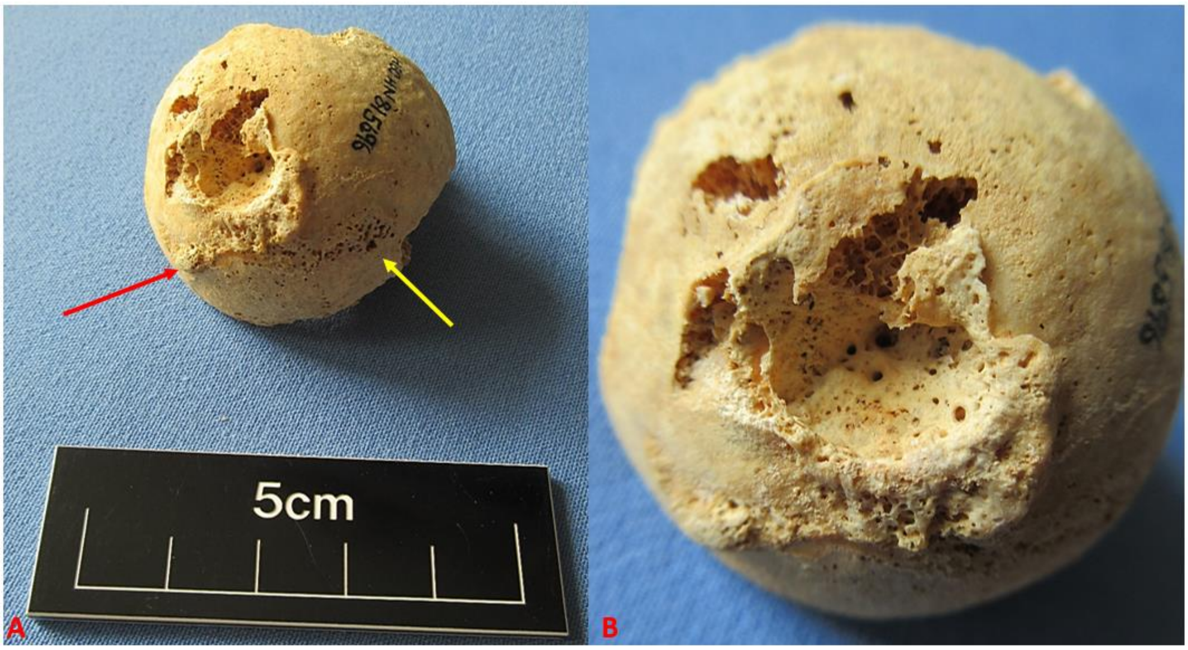


Figure 8.16: A - Right femoral head with arthritis of the hip from Hazleton North long barrow (Skeleton # 2) with surface osteophytes (red arrows) and porosity (yellow arrow). B – Detail.

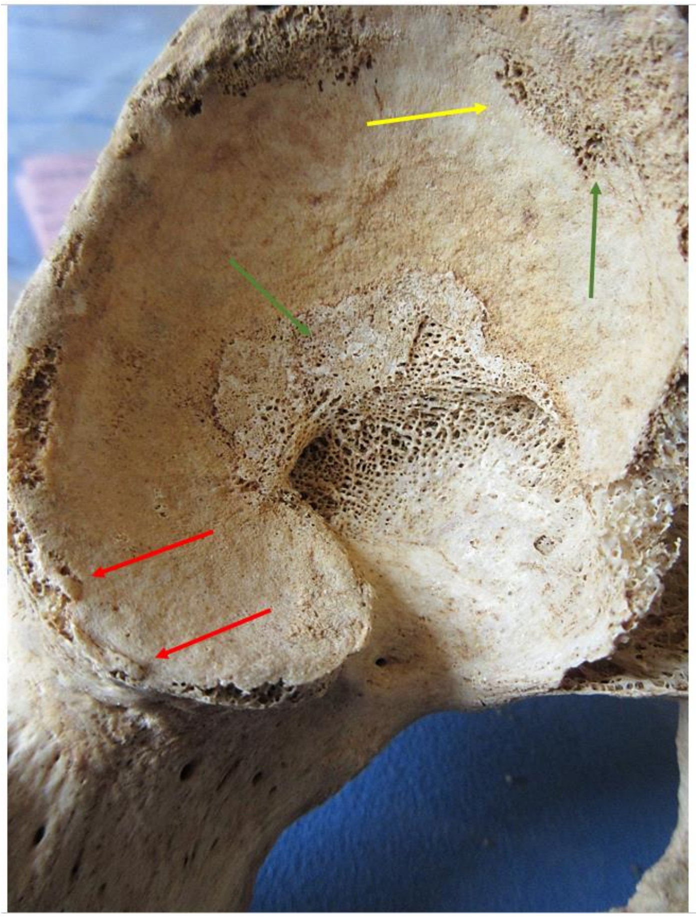


Figure 8.17: Right os coxae from adult male from Hazleton North long barrow (# 8498) with osteoarthritis of the hip joint - marginal osteophytes, (red arrows), porosity (green arrows), and eburnation, (yellow arrow).

8.2.9. Osteoarthritis of the Knee

Osteoarthritis of the knee is the most common form of the disease in modern populations, affecting more women than men, and is very strongly associated with obesity (Conaghan and Nelson 2012: 40; Coggon *et al.* 2001: 622). In modern populations, recent studies have shown that osteoarthritic changes in the knees affect 60% of males and 70% of females who die over the age of 60 (Arden and Cooper 2006: 9). The knee joint is comprised of three compartments – the patellofemoral joint, and the medial and lateral tibiofemoral joints, each joint having different aetiologies, risk factors and prevalences (Rogers and Waldron 1995: 42). Of the three compartments, the patellofemoral joint is the most commonly affected, followed by the lateral tibiofemoral and medial tibiofemoral joints respectively in modern populations (Resnick 2002c: 1350).

Analysis of the 42 sites for the current study revealed that three individuals suffered from osteoarthritis of the knee, giving a crude prevalence rate of 1% (3/305) (the reasons for such a low rate are the same as those outlined above). An adult female from Giant's Hills (Skendleby I) long barrow (EU.1.5.116), aged over 24 years, exhibited moderate marginal lipping/osteophytes in the intercondylar space, and macroporosity on the lateral condyle of the left femur (Figure 8.18). Unfortunately, the corresponding tibia was missing the proximal portion, impeding inspection of the whole joint. However, the left patella did not show any signs of osteoarthritis. The TPR for the left femur is 7.1% (1/14).

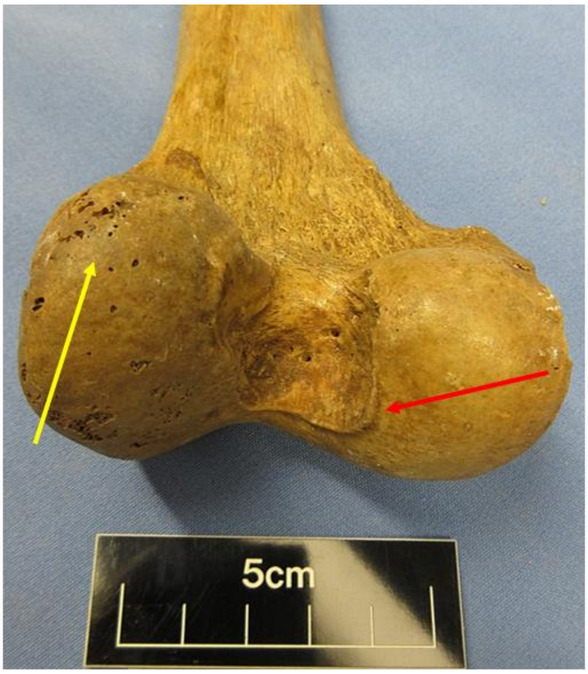


Figure 8.18: Left distal femur from adult female from Giant's Hills (Skendleby 1) long barrow (EU.1.5.116) with osteoarthritis of the knee in the form of marginal lipping in the intercondylar space (red arrow) and macroporosity on the lateral condyle (yellow arrow).

Two individuals from Hazleton North long barrow exhibited osteoarthritis of the knee. Skeleton # 2, an adult probable male, aged between 33 and 60 years of age, exhibited lipping/marginal osteophytes and porosity on the lateral condyle of the right femur, together with porosity and lipping/marginal osteophytes on the corresponding patella. Incidentally, this is the same individual featured in Figure 8.16 above, who also has osteoarthritis of the hip. Another right patella from Hazleton North long barrow (# 9321), which possibly belongs to an adult male, also exhibits osteoarthritis of the knee (Figure 8.19). This bone exhibits a suite of manifestations of the disease on the posterior: new bone formation; porosity; marginal lipping/osteophytes; and joint contour change. The TPR for the right femur is 1.8% (1/55) and 4.4% (2/45) for the right patella.

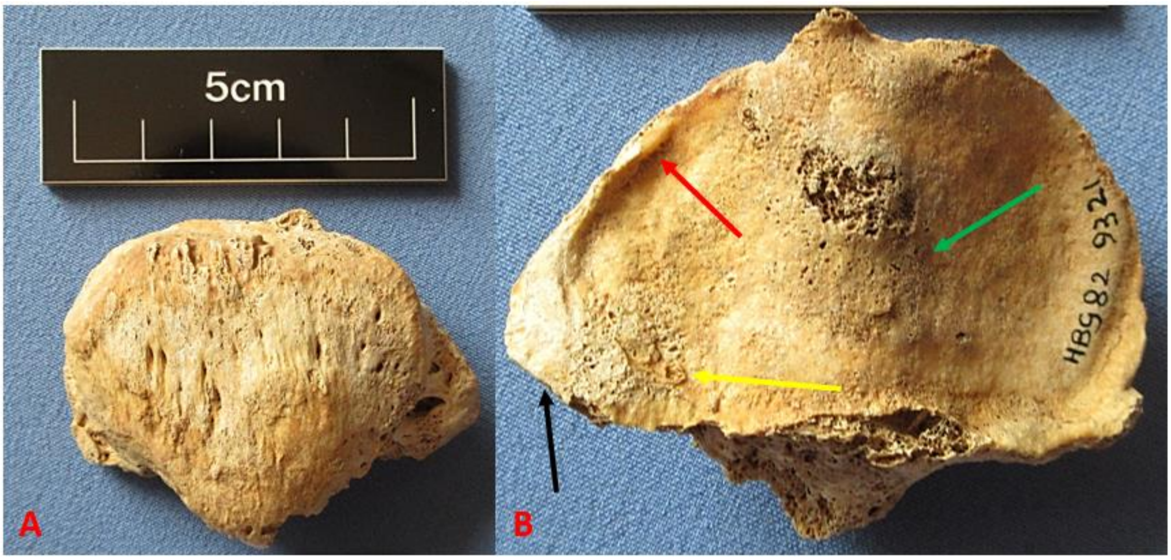


Figure 8.19: A - Right patella from Hazleton North long barrow (# 9321), anterior view. B – Posterior view: osteoarthritis of the knee in the form of new bone formation (yellow arrow), porosity (green arrow), marginal lipping (red arrow), and joint contour change (black arrow).

8.2.10. Osteoarthritis of the Ankle and Foot.

Despite being subjected to more weight-bearing force than any other joint in the human body, osteoarthritis of the ankle is uncommon, but where the disease is evident, the osteoarthritic changes may be due to altered mechanics of the bones following a fracture or dislocation (Waldron 2009: 38). Osteoarthritis of the foot usually only involves the first tarsometatarsal joint or the first metatarsophalangeal joint, but if other joints of the foot develop osteoarthritic changes, the cause is probably due to secondary osteoarthritis following trauma (Salter 1999: 266).

Four individuals in the current study exhibited evident of osteoarthritis of the foot and ankle, giving a CPR of 1.3% (4/305). Only one individual had osteoarthritic changes to the right first metatarsophalangeal joint, an adult male from West Kennet long barrow (EU.1.5.140), aged between 23 and 57 years, in the form of eburnation, porosity and marginal osteophytes on the head (Figure 8.20). The TPR for this element is 14.2% (1/7).

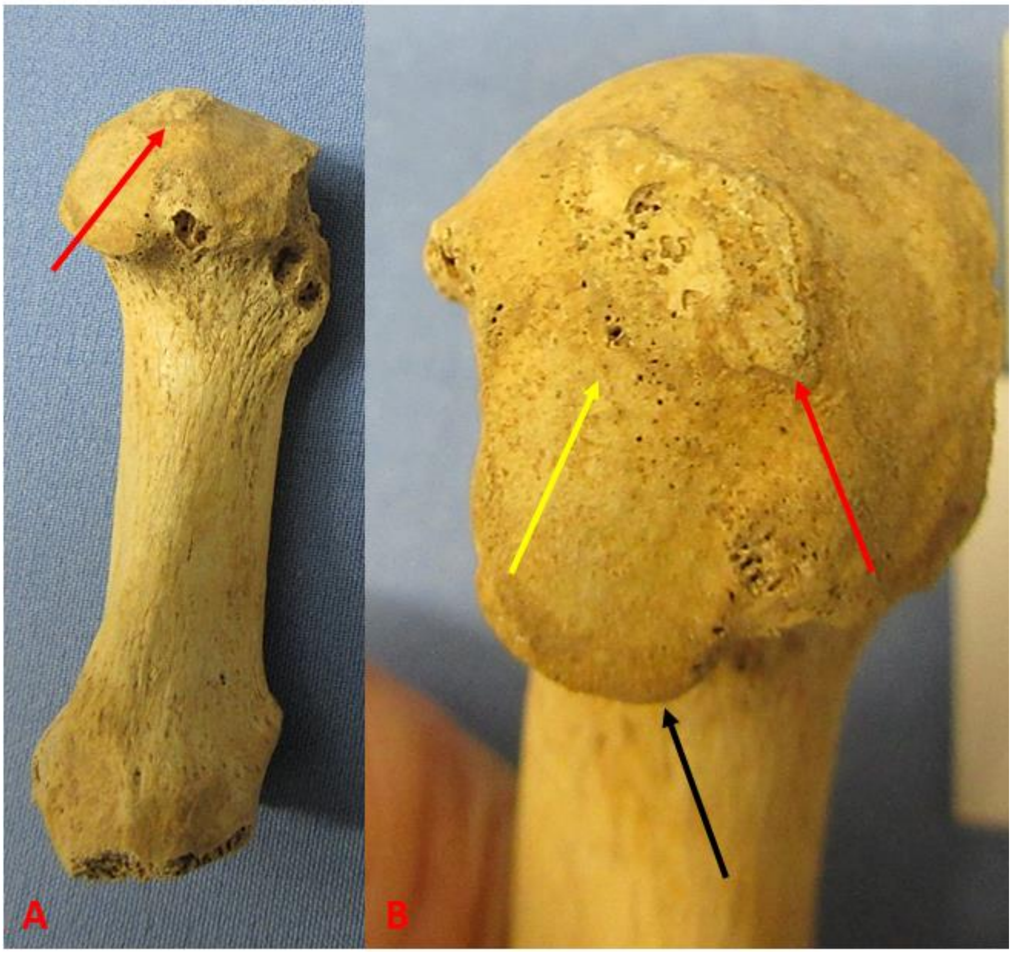


Figure 8.20: A - First right metatarsal from West Kennet long barrow (EU.1.5.140), with osteoarthritic changes to the head (red arrow indicating area of eburnation). B – Osteoarthritic changes in the form of porosity (yellow arrow), eburnation (red arrow), and marginal osteophyte (black arrow).

One adult probable male, aged between 33 and 60 years from Hazleton North long barrow (Skeleton # 2) exhibited signs of osteoarthritis of the foot on the proximal facet for the cuboid of the right fifth metatarsal, in the form of marginal osteophytes, lipping, and porosity. The TPR for this element is 1.9% (1/54). Another adult of unknown sex and age from Millbarrow (# 5899) exhibited osteoarthritic changes to the right second metatarsophalangeal joint in the form of eburnation, giving a TPR of 2% (1/51) for this element. Lastly, an individual from Hazleton North long barrow (Skeleton F), an adult female aged at least 40 years (featured in Figure 8.6, Section 8.2) exhibits osteoarthritic changes to the left talus in the form of joint contour change, osteophytes and porosity. However, this individual may have suffered trauma to the ankle, as osteoarthritic changes to the talus are very uncommon. The TPR for this element is 50% (1/2).

8.2.11: Summary

Sixteen sites out of the 42 studied (38%, 16/42) contained individuals with evidence of osteoarthritis (Table 8.9), affecting at least 23 adults (7.5%, 23/305).

Table 8.9: Sites with evidence of osteoarthritis.

Site	Age	Sex	Joint Affected
Belas Knap DI	30-54	F	TMJ
Belas Knap BII	25-35	M	TMJ
Broadsands (un-numbered)	?	?	Marginal enthesophytes vertebra
Fromefield (un-numbered)	?	?	Distal interphalangeal (hand)
Giant’s Hills (Skendleby 1) EU.1.5.115	24+	F	Hip
Giant’s Hills (Skendleby 1) EU.1.5.116	24+	F	Knee
Handley 27	40-60	M	Hip
Hazleton North (Skeleton A)	23-57	M	Sternoclavicular; apophyseal joints of vertebrae and marginal enthesophytes; shoulder; wrist
Hazleton North (Skeleton F)	40+	F	Sternoclavicular joint; apophyseal joints vertebrae; shoulder; ankle
Hazleton North (Skeleton 1)	40-45	M	Apophyseal joints vertebrae; shoulder
Hazleton North (Skeleton 2)	33-60	M?	Atlantoaxial; hip; knee; foot
Hazleton North # 4788	45+	UND	TMJ
Hazleton North # 11456	45+	UND	TMJ
Hazleton North # 14338	?	UND	Atlantoaxial
Hazleton North # 9906	?	UND	Atlantoaxial
Hazleton North # 7859	?	UND	Atlantoaxial
Hazleton North # 5892	?	UND	Marginal enthesophytes vertebrae
Hazleton North # 6277	?	UND	Hand
Hazleton North# 9034, 9833, 6533, 9831, 9233	?	UND	Hand
Hazleton North # 4515,	?	UND	Hip
Hazleton North # 8498	45+	M	Hip
Hazleton North # 9321	?	M?	Knee
Hetty Pegler’s Tump (Uley)	?	?	Atlantoaxial
Kings Playdown (Heddington 3)	33-45	M	TMJ
Lanhill (EU.1.5.104)	39-56	M	TMJ; apophyseal joints vertebrae; marginal enthesophytes vertebrae; atlantoaxial
Lanhill (EU.1.5.105)	50+	F	Atlantoaxial
Lanhill (EU.1.5.106)	25-35	M	Elbow
Luckington (Giants Grave)	?	?	Apophyseal joints vertebrae; marginal enthesophytes vertebrae; distal interphalangeal (hand)
Millbarrow (un-numbered)	?	?	Atlantoaxial; metatarsophalangeal
Nympsfield (un-numbered)	?	?	Atlantoaxial; TMJ
Rodmarton (un-numbered)	?	?	Elbow
Tilshead Old Ditch	48-56	F	TMJ
Wor Barrow (Skeleton 5)	33-45	F?	Elbow (left and right)

West Kennet (EU.1.5.140)	**23-57**	**M**	**Apophyseal joints vertebrae; elbow; foot**
West Kennet SE chamber	**?**	**UND**	**Apophyseal joints vertebrae**
West Kennet NW chamber	**?**	**UND**	**Apophyseal joints vertebrae**

Seventy per cent of the individuals affected by osteoarthritis (16/23) could be assigned a sex category, which could be separated into eight males and one probable male, six females and one probable female. Initially, it would seem that more males than females were affected by the disease in this study, which does not follow the pattern in modern populations, but when the TPR is adjusted for sex, females had a higher prevalence of osteoarthritis than males in the hip (8.3%, 1/12 versus 7.1%, 1/14 on the proximal femur) and 17% (1/6) versus 8.3% (1/12) on the ossa coxae. However, the female was only affected on the left side, and the male on the right, so a comparison in the case may not be valid. The sterno-clavicular joint was affected in 100% (1/1) of females and 10% (1/10) of males on the manubrium, but the right clavicle was affected in 5.9% (1/17) of females and 6.25% (1/16) of males. However, males had a higher prevalence of osteoarthritis in the shoulder, with 9.1% (1/11) versus 5.3% (1/19) of left clavicles affected, and 11.8% (2/17) for the right versus 6.25% (1/16) in females.

Seven individuals (2.3%, 7/305) had evidence of osteoarthritis in more than one joint. All of the individuals, except the probable female from Wor barrow (Skeleton 5) had osteoarthritis of the spine, but this individual did not have any extant vertebrae to examine. Three of the individuals (43%, 3/7) had osteoarthritis of the shoulder, and two (29%, 2/7) had osteoarthritis of the sternoclavicular joint. However, Skeleton # 2 from Hazleton North long barrow may have been the most affected by the disease. This individual has evidence of osteoarthritis in the right hip, knee, foot, and vertebrae, probably limiting mobility and causing a degree of discomfort, together with a stiffness and limited range of movement in the neck region.

8.3. Diffuse Idiopathic Skeletal Hyperostosis (DISH)

Diffuse Idiopathic Skeletal Hyperostosis (DISH) is also known as ankylosing hyperostosis or Forestier's disease (Ortner 2003: 558). The most characteristic manifestation of the disease is the prolific vertical osteophytes that flow down the right anterolateral surface of the vertebral bodies of the thoracic spine, and on either side of the vertebral bodies in the other sites (Resnick 2002e: 1477). In addition, enthesophytes will be evident elsewhere in the skeleton where tendons insert, such as the linea aspera of the femur, the deltoid tuberosity of the humerus, the tuberosity of the radius, the Achilles tendon into the posterior of the calcaneus, and the insertion of the M. *quadriceps femoris* into the patella (Rogers *et al*. 1987: 186). Furthermore, new bone growth may be evident on the ossa coxae, either along the iliac crest or on the ischial tuberosity, or in ossified cartilage elsewhere (Rogers *et al*. 1987: 188). The disease does not interfere with the intervertebral space, and the vertebral end plates are also spared (Resnick 2002e: 1477). The apophyseal joints are not affected by DISH either, unless another condition such as osteoarthritis is also present (Rogers *et al*. 1987: 187). The operational definition for DISH is the ossification and fusion of four contiguous thoracic vertebrae, where the bodies have fused on the right lateral aspect, and ossification into extra-spinal entheses and ligaments (Waldron 2009: 77).

In modern populations, DISH is found more commonly in males than females, and typically affects those over the age of 40 (Waldron 2009: 74). Clinical studies have shown that the disease in individuals over this age affects 4% of males and 2.5% of females (Mata *et al*. 1997), but Julkunen (1971: 611) reported that the incidence in the Finnish population was as high as 8.4% in males and 4.3% in females (in the 60 to 69 year group), with a strong link (25%) to obesity and diabetes type II. Following the findings that DISH is more prevalent in over-weight individuals who develop late-onset diabetes, Rogers and Waldron (2001) state that there is a real link between individuals in past populations with DISH and a high status and abundantly calorific diet. Rogers and Waldron examined the adult skeletons from Wells Cathedral and the Royal Mint site in London, and found a high prevalence of the disorder in skeletons buried inside the Cathedral; 13.3% in the Lady Chapel, and 23.1% in Stillington's Chapel, compared to only 6.5% in the lay cemetery (Rogers and Waldron 2001: 360). Furthermore, the burials at the Royal Mint site confirmed the connection, with no cases of DISH out of the ninety-nine buried in the Lay cemetery, but six out of the 52 (11.5%) burials in the church and chapels had the disorder (Rogers and Waldron 2001: 361).

According to Rogers and Waldron (2001), the reason why monks and lay benefactors at Wells Cathedral and the Royal Mint site should exhibit such a high prevalence of DISH compared to the ordinary folk buried in the cemeteries outside, is attributable to the rich diet enjoyed by the privileged classes (2001: 361). Examination of the rolls of Westminster Abbey has revealed the extent of the lifestyle enjoyed by the Monks therein: the average allowance of calories outside of Advent or Lent was 6207 per day, 5291 and 4870 during Advent and Lent respectively (Harvey 1993: 64). Even if the monks only consumed 60% of their daily allowance and gave the rest to the poor, they would still be consuming 3723 calories on an average day, far more than the recommended daily intake today (Rogers and Waldron 2001: 361). The authors surmise that the high daily intake of calories would have increased the likelihood of obesity and diabetes, thereby predisposing the monks to DISH (Rogers and Waldron 2001: 362).

One individual in the current study of the human remains from 42 sites exhibited signs of DISH, giving a crude prevalence rate of 0.3% (1/305). Skeleton A from Hazleton North long barrow is a mature adult male, aged between 23 and 57 years of age (based on the method of aging the pubic symphysis by Brooks and Suchey, 1990), although the individual is considered to be nearer to the later age estimate based on the presence of only one very worn tooth (a right 1st premolar, the rest of the maxilla is edentulous with all of the teeth having been lost ante mortem), and osteoarthritic changes to the wrist, clavicles, and cervical vertebrae. Skeleton A is only 40.2% complete (based on the Zonation Method of Knüsel and Outram, 2004) and was excavated from the north entrance of the monument (Saville 1990: 125). Nevertheless, this individual has flowing enthesophytes on the right side of the anterior bodies of the existing two contiguous thoracic vertebrae, and the joint space has been spared between the vertebral bodies (Figure 8.21). Furthermore, all five lumbar vertebrae are fused, with flowing enthesophytes running vertically down the anterior bodies on the left side, and the joint spaces between the vertebral bodies are unimpaired (Figure 8.22). In addition, this individual has enthesophytes on both patellae (insertion for *M. quadriceps femoris* – Figure 8.23A), the left calcaneus (insertion for Achilles tendon), both pubic tubercles (Figure 8.23C), the posterior of the right pubis (insertion for *M. obturator externus*), the right proximal fibula (insertion for *M. peroneus fibularis*), and ossified costal cartilage of a fragment of rib (Figure 8.23B).

Figure 8.21: Ninth and tenth thoracic vertebrae from Skeleton A, Hazleton North long barrow, with flowing enthesophytes to the anterior right of the vertebral bodies (red arrows), and uninvaded joint space (yellow arrow).

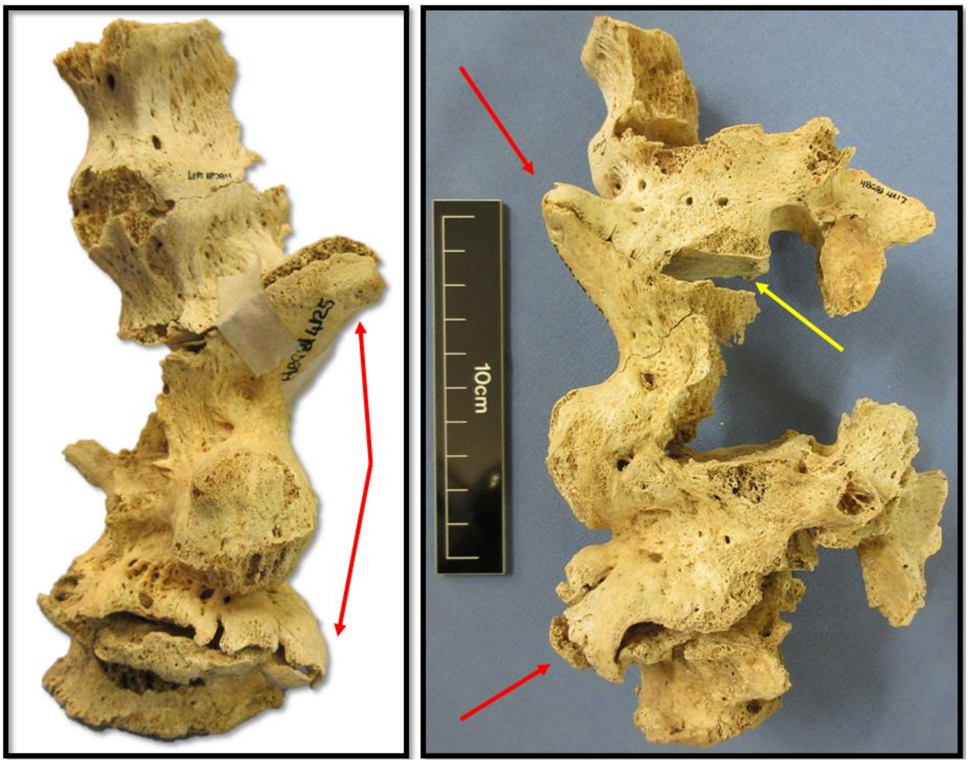


Figure 8.22: Five contiguous lumbar vertebrae from Skeleton A, Hazleton North long barrow, with flowing enthesophytes to the anterior left of the vertebral bodies (red arrows), and uninvaded joint space (yellow arrow).

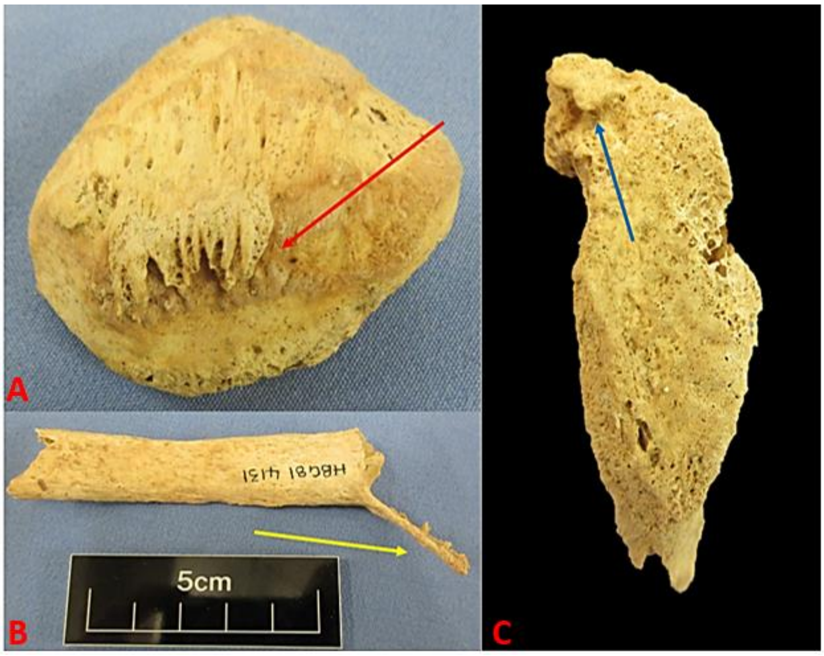


Figure 8.23: A - Left patella with enthesophytes (red arrow) from Skeleton A Hazleton North long barrow where *M. quadriceps femoris* inserts. B - Rib fragment with ossified costal cartilage (yellow arrow). C - Enthesophyte on right pubis where the superior pubic ligament inserts.

8.4 Ankylosing Spondylitis

Ankylosing spondylitis (AS) is an inflammatory disease which progresses with age and commonly affects the sacroiliac joints, those of the spinal column, and the costo-vertebral joints (Resnick 2002f: 1025). The disease is characterised by bilateral sacro-ilitis, new bone formation on the vertebral bodies and apophyseal joints, which in extreme cases fuse completely to produce bamboo spine (Rogers *et al*. 1987: 188). The fusion of the vertebral column commences in the lumbar region, and extends upwards, without missing any of the subsequent vertebrae, and leaving no spaces in between the bodies (Rogers and Waldron 1995: 66). AS may also affect the extraspinal joints unilaterally - the hip, shoulder and knees are the most common sites (Waldron 2009: 59).

AS is twice more common in males than females and typically begins in the third decade of life (Braun and Sieper 2007: 1379). The aetiology of the disease is unclear but it has been suggested that there is a strong genetic link, as individuals who suffer from the condition have high levels of a tissue antigen called HLA-B27 in 95% of cases (Brown *et al*. 2000: 883).

The examination of the human skeletal remains from 42 sites for the current study revealed one possible case of AS, giving a crude prevalence rate of 0.3% (1/305) for the disease. Skeleton 4 from Wor Barrow, a mature adult male of between 40 and 45 years of age, was found to be only 23.6% complete (based on the Zonation Method of Knüsel and Outram 2004). However, the individual suffered bilateral fusion of the *ossa coxae* to the sacrum. The sacro-iliac joints are very irregular and marked by large enthesophytes, with porosity on the surface of the ilium (Figure 8.24). Unfortunately, none of the vertebrae were preserved, thereby negating the operational definition for AS – bilateral fusion of the sacro-iliac joints *and* fusion of the spine with no skip lesions (Waldron 2009: 59).

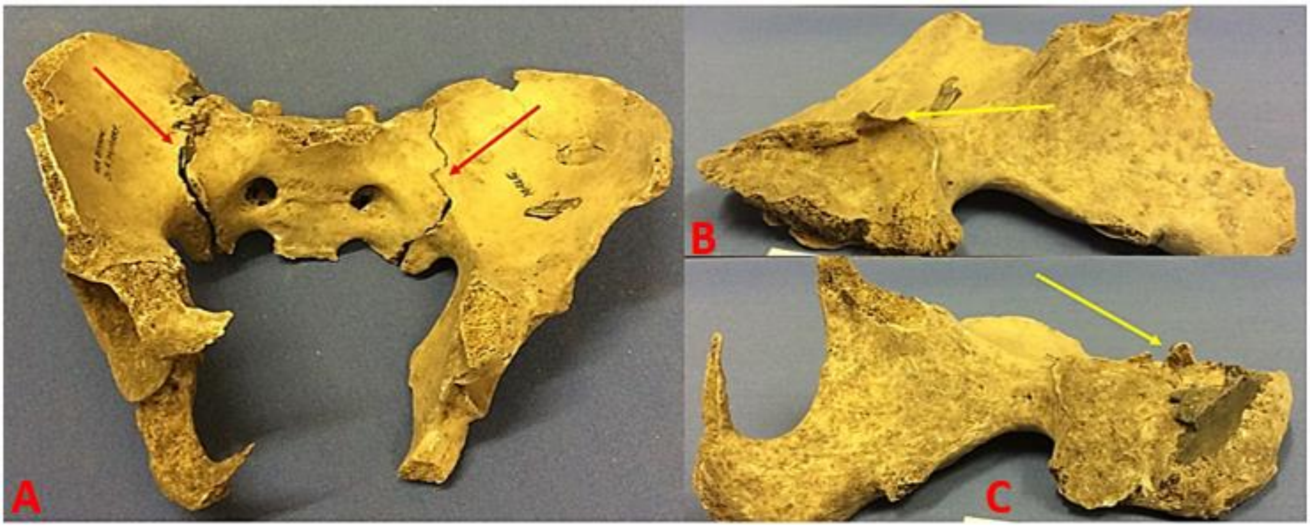


Figure 8.24: A - Skeleton 4 from Wor Barrow, with bilateral fusion of the sacro-iliac joints, displaying irregular joint margins (red arrows), and marked enthesophytes (yellow arrows) on the left (B) and right (C) os coxae.

8.5: Septic Arthritis

Septic arthritis is a disease of the synovial joints, caused by the infiltration of bacteria, most commonly *Staphylococcus aureus,* into the synovial space (Waldron 2009: 89). The invading bacteria cause an inflammatory response within the synovium, resulting in destruction of the articular cartilage (Nade 2003: 183). Erosions may form within the joint, and without antibiotic treatment, bony ankylosis may follow the pyrogenic process (Resnick 2002b: 2430). The bacteria may enter the affected joint via the haematogenous route or by direct implantation through trauma, or iatrogenically i.e. infection introduced unintentionally by a physician (Matthews *et al.* 2010: 848). Risk factors for acquiring septic arthritis include those individuals who are immunosuppressed, patients with joint disease, especially rheumatoid arthritis and osteoarthritis, and individuals who currently wear a joint prosthesis (Kaandorp *et al*. 1995: 1819). In addition, individuals with diabetes, alcoholism, cutaneous ulcers, of low socio-economic status, and those who have received a previous intra-articular corticosteroid injection are at risk of developing septic arthritis (Matthews *et al*. 2010: 847).

Modern cases of septic arthritis are uncommon. Nade (2003:184) reports an incidence of six cases per 100,000 in New Zealand, with a figure of between two and five per 100,000 per year reported for the general Dutch population (Kaandorp *et al*. 1995: 1819). Clinical studies give figures of between four and ten per 100,000 per year in western Europe, but a higher incidence in disadvantaged groups in northern Europe and indigenous populations of Australia, where the prevalence reached 29 per 100,000 per year (Matthews *et al*. 2010: 846). Kaandorp and colleagues (1995: 1822) also report an increase in prevalence with age and those suffering from diabetes by a factor of 3.5 and 3.3 respectively.

Patients with septic arthritis may present with a red and painful joint, which has restricted movement, and if the individual also suffers from osteoarthritis, the septic joint will show symptoms which are out of proportion with the suffering caused by those affected by osteoarthritis (Matthews *et al*. 2010: 849). Additional symptoms may include a fever, sweating and rigors, with a mortality rate of approximately 11%, if untreated with antibiotics and aspiration of the pus from the joint (Matthews *et al*. 2010: 850). Very few cases of septic arthritis have been reported for archaeological specimens, and none for the Neolithic period.

One individual from the current study is suspected of suffering from septic arthritis, giving a CPR of 0.3% (1/305). The adult male, aged between 23 and 57 years, was excavated from Hazleton North long barrow (Skeleton A), and has ankylosis of the joint between the second and third left metatarsals (Figure 8.25), giving a TPR of 25% (1/4) for the second metatarsal and 25% for the third (1/4).

Figure 8.25: A- Ankylosis of the left second and third metatarsal of Skeleton A Hazleton North long barrow, dorsal view. B – Plantar view.

This individual is strongly suspected of having septic arthritis in the joint between the second and third left metatarsals for three reasons. The presence of bony ankylosis to the joint is indicative of the disease but may also be present following trauma. However, this individual also has osteoarthritis of the sternoclavicular joint (both left and right), the acromioclavicular joint (both left and right), the apophyseal facets of some vertebrae, plus marginal enthesophytes on the bodies, and osteoarthritis of the wrist. He is also considered to have suffered from DISH, which is strongly associated with individuals who suffer from diabetes. This condition is associated with sensory loss to the foot, thereby increasing the risk of injury to the extremities through barefoot walking or trauma (Waldron 2009: 89). A diagnosis for septic arthritis for this individual is therefore likely.

8.6 Degenerative Conditions of the Vertebral Column

8.6.1 Intervertebral Disc Disease

The vertebral bodies articulate with each other via the intervertebral disc, which is composed of the annulus fibrosis (the fibrous outer ring), which surrounds the central portion, or nucleus pulposus (Waldron 2009: 43). The disc is surrounded by Sharpey's fibres, which hold it firmly in place, but traction placed on the annulus fibrosis causes the fibres to displace, initiating the formation of enthesophytes on the vertebral body margins (Burt *et al*. 2013: 57). In addition, disruption to the intervertebral discs causes pitting on the superior and inferior surfaces of the vertebral bodies, typically those of the cervical and lumbar region (Rogers and Waldron 1995: 27). Intervertebral disc disease should not be confused with osteoarthritis of the spine as it does not involve the suite of other changes associated with that disease (porosity, eburnation etc.). It is however, a progressive condition linked to individuals over the age of 40 and affects males and females equally (Resnick 1985: 6; Waldron 2009: 43).

Only three sites from the current study revealed any evidence of intervertebral disc disease, and on only five vertebrae, representing at least three individuals, giving a crude prevalence rate of 1% (3/305). One cervical vertebra from Avenis long barrow (# 1950:282), a cervical (# GC/A/1) and a lumbar vertebra (# GC/D/2) from Luckington long barrow, two lumbar vertebrae from Hazleton North long barrow (# 5945 and # 8165) (Figure 8.26) were affected. All had pitting and marginal enthesophytes on the vertebral bodies.

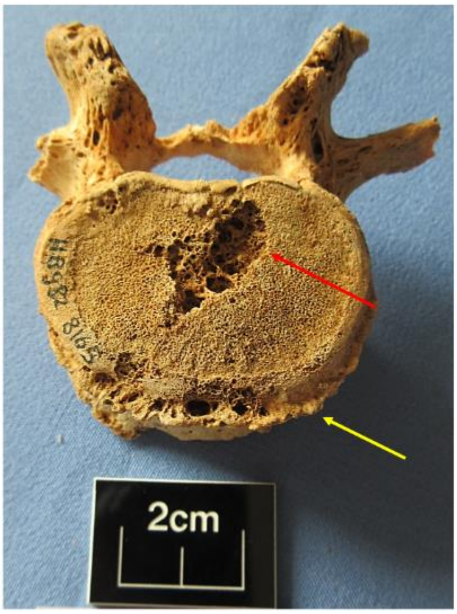


Figure 8.26: Lumbar vertebra from Hazleton North long barrow with degenerative disc disease (pitting, red arrow; marginal enthesophytes, yellow arrow).

8.6.2: Schmorl's Nodes

Schmorl's nodes develop when the vertebral endplate decompresses the adjacent nucleus pulposus, transferring the load onto the surrounding annulus fibrosis, causing a herniation into the damaged part of the endplate (Rogers and Waldron 1995: 27). Schmorl's nodes are easily recognisable in skeletal assemblages, resembling shallow depressions in the superior or inferior surfaces of the vertebral bodies (Burt *et al*. 2013: 60). The aetiology of the condition is not clear but has been linked to compression of the spine, but with infection, neoplastic disease or osteoporosis causing a deterioration in the quality of the body, allowing the condition to develop (Resnick 2002d: 1430).

The current study found that five sites from the 42 examined had evidence of Schmorl's nodes, affecting at least five individuals, giving a crude prevalence rate of 1.6% (5/305). An adult male from Giant's Hills (Skendleby I) long barrow (#EU.1.5.114) had Schmorl's nodes on three of the lumbar vertebrae, on both the superior and inferior surfaces (Figure 8.27). Skeleton 1 from Hazleton North long barrow exhibited the condition on a thoracic vertebra, on the superior and inferior sides of the vertebral body. The last three sites had disarticulated vertebrae, which were not assigned to any one skeleton: Haddenham long barrow had a partial lumbar vertebra (HAD 87) with a Schmorl's node on the superior surface; Luckington long barrow had a lumbar vertebra (# GC/D/2) with this condition on the inferior surface; and West Kennet had an un-numbered lumbar vertebra from the south-west chamber with Schmorl's nodes on both the superior and inferior surfaces. The TPR for the thoracic vertebra is 0.2% (1/411), and 3.3% (6/183) for the lumbar vertebrae.

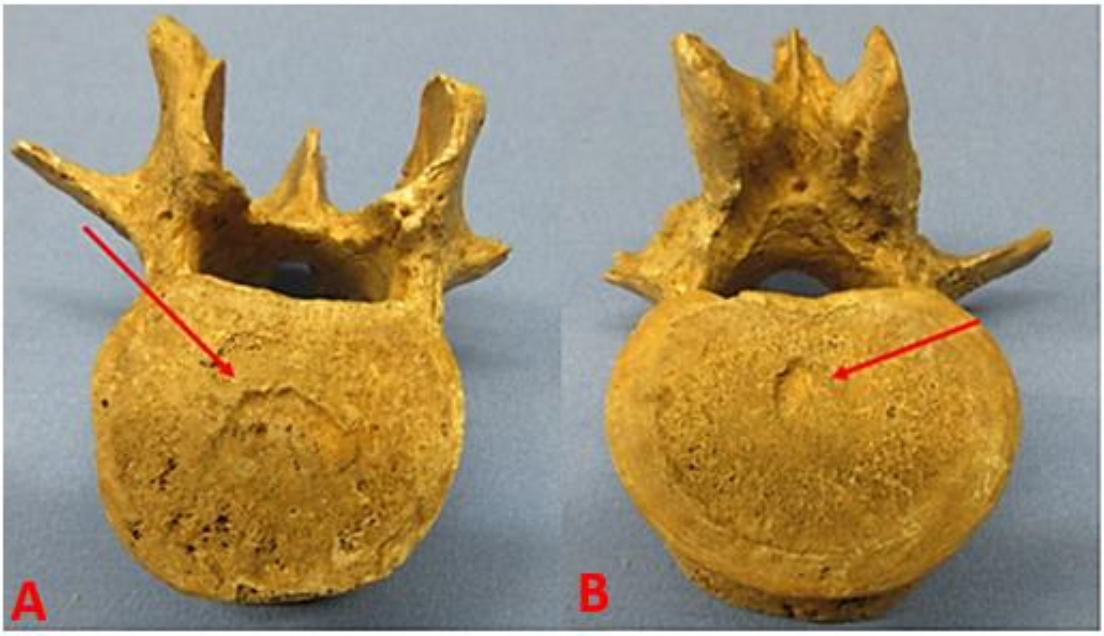


Figure 8.27: A - Lumbar vertebra from a male individual from Giant's Hills (Skendleby I) long barrow, with Schmorl's nodes to the superior surface. B – Inferior surface.

8.7. Summary

At least 32 individuals (10%, 32/305) exhibited evidence of joint disease in the current study. A minimum of 23 individuals had evidence of osteoarthritis (7.5%, 23/305), with the most people affected by osteoarthritis of the spine in the apophyseal joints (3%, 9/305). Of the individuals affected by osteoarthritis, 2.3% (7/305) had the disease in more than one joint. Skeleton #2 from Hazleton North long barrow was the most affected individual, with osteoarthritis of the right hip, knee and foot and spine. However, another adult male from this site is likely to have suffered from several conditions at once. Not only does this individual have osteoarthritis of the spine, shoulder, sternoclavicular joint and wrist, he is considered to have suffered from DISH. This condition is strongly related to individuals who are overweight and suffer from diabetes. In addition, Skeleton A has ankylosis of two metatarsals, strongly suggestive of septic arthritis, (a condition previously unreported in the Neolithic period) which .individuals with osteoarthritis and diabetes are particularly susceptible to. A possible case of ankylosing spondylitis was outlined from an individual from Wor Barrow which has not been reported before.

There was scant evidence for degenerative disc disease from the current study, with only five vertebrae showing any signs of the disease, representing at least three people (1%, 3/305). Additionally, only five individuals had evidence of Schmorl's nodes (1.6%, 5/305), which is not a very significant figure. The reasons why degenerative disc disease was under-represented in the current study is probably due to the lack of vertebrae retained following excavation. In total, there were only 180 cervical, 411 thoracic and 183 lumbar whole vertebrae available for examination. This accounts for only 8.4% (180/2135), 11% (411/3660), and 12% of the expected total (out of a MNI of 305). Thirty-two of the sites had no whole vertebrae at all, accounting for 76% (32/42) of the total, the reasons being either damage during excavation, taphonomic, or worse, being left in the monument as these elements, along with many others, were considered unimportant by the excavators who prized crania above everything else.

Chapter 9: Dental Disease

9.1 Introduction

The durability and structure of teeth permits them to survive extremely well in the archaeological record, in consistently greater volumes than that of the more fragile bone. This situation is somewhat ironic, given that "no structures of the human body are more likely to disintegrate during life than teeth, yet after death none have greater tenacity against decay" (Wells, 1964: 121). The analysis of teeth from archaeological sites allows inferences about past diet, health, and cultural practices to be made. In addition, teeth are a very reliable resource to aid in determining the age at death of skeletal human remains. In recent years, new techniques have allowed further insights into the lives of past populations through analysis of the dentition. Oxygen and strontium isotope analysis of teeth can indicate the origins of archaeological skeletal material, an important issue when discussing the migration of people during the prehistoric period. One such important discovery was that of the Amesbury Archer, who was buried near Stonehenge in Wiltshire, and was dated to 2380-2290 cal BC (Barclay *et al.* 2011: 169). Following isotopic analysis of his teeth, it was evident that the burial was not that of a local inhabitant, but of an individual who had likely grown up in the Alpine region between Germany and Scandinavia (Chenery and Evans 2011: 87). Therefore, the survivability of the dentition in archaeological sites is invaluable to researchers to make inferences about past peoples, and especially to assess their health by studying dental disease.

9.2: Dental Inventory

Figure 9.1 and Table 9.1 below details the dentition available for analysis from the 42 sites in the current study.

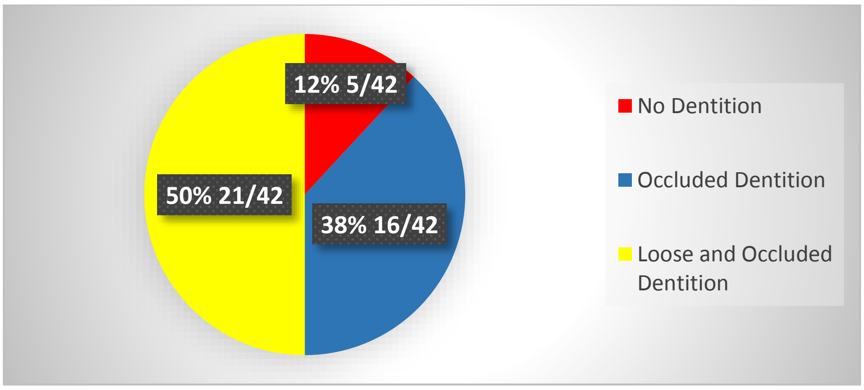


Figure 9.1: Proportion of dentition available for study.

Five of the sites, equating to 12% of the total (Chestnuts, Horton Down, Lamborough Banks, Stoney Littleton, and West Tump) did not feature any dentition whatsoever, but 50% (21/42) of the sites had human remains with the dentition in occlusion, and no loose teeth. Conversely, 36% (16/42) of sites had skeletal remains that had both occluded and loose dentition available for study (Figure 9.1). Out of a MNI of 305, 192 individuals had a dentition that was available for analysis. Of these individuals, 57 were male or probable male, 44 were female or probable female, 64 were unsexed, and the last 27 were children.

Table 9.1: Sites with numbers of teeth in occlusion and loose teeth.

SITE	MNI	# Individuals With Dentition Present	# Teeth in Occlusion	# Sockets	# Loose Teeth	Total
Avening	3	3	13	31	15	28
Avenis (Smart's Farm)	5	3	6	30	6	12
Belas Knap	19	15	117	302	6	123
Bown Hill (Woodchester)	3	3	6	26	6	12
Bratton Camp	1	1	11	32	0	11
Broadsands	6	2	3	20	9	12
Chestnuts	7	0	0	0	0	0
Figheldean Down (31)	1	1	13	15	0	13
Fittleton Down (5)	1	1	10	12	0	10
Fromefield	18	4	20	31	51	71
Fyfield (Giants Grave)	2	2	34	55	0	34
Gatcombe Lodge	1	1	22	32	0	22
Giant's Hills (Skendleby I)	6	3	53	62	1	54
Haddenham	5	4	7	38	5	12
Handley 26	1	1	11	16	18	29
Handley 27	1	1	18	28	0	18
Hazleton North	41	30	235	450	206	441
Hetty Pegler's Tump (Uley)	5	4	30	79	0	30
Horton Down (Bishops Cannings 91)	1	0	0	5	0	0
Imber (Bowls Barrow)	5	3	29	57	1	30
Jackbarrow	3	3	20	44	0	20
Kings Playdown (Heddington 3)	1	1	26	31	0	26

Lamborough Banks (Ablington)	1	0	0	0	0	0
Lanhill	8	6	62	115	0	62
Littleton Drew (Lugbury)	12	8	82	137	0	82
Luckington (Giants Cave)	11	4	32	63	26	58
Millbarrow	8	4	9	21	59	68
Netheravon Down (6)	2	2	22	27	0	22
Norton Bavant	12	3	37	42	0	37
Nympsfield	9	7	46	97	0	46
Oldbury Hill	3	2	14	30	0	14
Randwick	3	2	15	22	13	28
Rodmarton	12	12	60	126	0	60
Stonehenge (Amesbury 14)	3	1	9	13	0	9
Stoney Littleton	2	0	0	0	0	0
Tilshead East (7)	8	3	22	38	0	22
Tilshead Lodge	2	2	23	41	0	23
Tilshead Old Ditch	1	1	20	28	0	20
West Tump (Cranham)	1	0	0	0	0	0
Winterbourne Monkton	22	15	157	242	0	157
Wor Barrow	7	5	73	142	26	99
West Kennet	42	29	283	503	13	296
TOTAL	305	192	1650	3083	461	2111

Table 9.2 gives the occluded dentition at sites according to sex (where possible). The total number of teeth in occlusion was 1650, but 254 could not be assigned a sex. Furthermore, 127 of the teeth were deciduous. There were 3083 sockets in the assemblage, which are also detailed by sex in Table 9.2 in red brackets (for the full number of sockets see Table 9.5).

Table 9.2: Occluded dentition by sex and numbers of sockets (in red).

SITE	Male	Male?	Female	Female?	UND	Deciduous
Avening	0	0	0	0 (8)	13 (23)	0
Avenis (Smart's Farm)	0	0	0	0	6 (30)	0
Belas Knap	40 (92)	10 (58)	26 (82)	11 (35)	0	30 (35)
Bown Hill (Woodchester)	0	0	0	3 (15)	3 (11)	0
Bratton Camp	0	0	0	11 (32)	0	0
Broadsands	0	0	0 (6)	1	2 (14)	0
Chestnuts	0	0	0	0	0	0
Figheldean Down (31)	0	0	0	0	13 (15)	0

Fittleton Down (5)	0	10 (12)	0	0	0	0
Fromefield	0	0	0	0	13 (28)	7 (3)
Fyfield (Giants Grave)	34 (55)	0	0	0	0	0
Gatcombe Lodge	22 (32)	0	0	0	0	0
Giant's Hills (Skendleby I)	29 (38)	0	24 (24)	0	0	0
Haddenham	0	0	0	0	6 (38)	1
Handley 26	0	0	11 (16)	0	0	0
Handley 27	18 (28)	0	0	0	0	0
Hazleton North	38 (48)	56 (109)	4 (12)	34 (69)	57 (100)	46 (112)
Hetty Pegler's Tump (Uley)	18 (24)	2 (13)	0	5 (19)	5 (23)	0
Horton Down (Bishops Cannings 91)	0	0	0	0	0 (5)	0
Imber (Bowls Barrow)	1 (1)	0	15 (24)	0	13 (32)	0
Jackbarrow	14 (16)	0	6	0 (28)	0	0
Kings Playdown (Heddington 3)	26 (31)	0	0	0	0	0
Lamborough Banks (Ablington)	0	0	0	0	0	0
Lanhill	47 (98)	0	15 (17)	0	0	0
Littleton Drew (Lugbury)	17 (25)	6 (19)	40 (64)	0	19 (29)	0
Luckington (Giants Cave)	0	0	9 (14)	14 (25)	4 (6)	5 (18)
Millbarrow	0	0	0	0	7 (13)	2 (8)
Netheravon Down (6)	20 (22)	0	0	0	2 (5)	0
Norton Bavant	13 (16)	0	24 (26)	0	0	0
Nympsfield	2 (2)	14 (26)	11 (27)	0 (7)	17 (33)	2 (2)
Oldbury Hill	0	11 (16)	1 (10)	0	2 (4)	0
Randwick	15 (22)	0	0	0	0	0
Rodmarton	0	0	15 (45)	12 (23)	29 (48)	4 (10)
Stonehenge (Amesbury 14)	0	0	9 (13)	0	0	0
Stoney Littleton	0	0	0	0	0	0
Tilshead East (7)	0	0	20 (29)	0	0	2 (9)
Tilshead Lodge	23 (41)	0	0	0	0	0
Tilshead Old Ditch	0	0	20 (28)	0	0	0
West Tump (Cranham)	0	0	0	0	0	0
Winterbourne Monkton	70 (89)	43 (77)	42 (74)	0	0	2 (2)
Wor Barrow	62 (110)	0	11 (32)	0	0	0
West Kennet	76 (115)	32 (36)	81 (141)	25 (63)	43 (105)	26 (43)
TOTALS	585 (905)	184 (366)	384 (684)	116 (324)	254 (562)	127 (242)
	1650 (3083)					

9.3: Infectious Disease

9.3.1 Dental Caries

Dental caries is the most common form of dental disease and involves the destruction of the heavily mineralised enamel, the tough dentine, and the cement that covers the root of the tooth (Hillson 2005: 290). The demineralisation of the tissues of the teeth is caused by the fermentation of carbohydrates, especially sugars, by bacteria which are present in plaque. This process produces acid capable of dissolving the enamel, and results in minor carious lesions such as opaque spots, or much larger cavities (Hillson 2002: 269). Lactic acid is the main acid present in plaque fluid following exposure to sugars, and was found, in experiments, to double in concentrate just seven minutes after rinsing with a sucrose wash (Margolis and Moreno 1994: 18).

Natural sugars are found in fruit and honey, in the form of fructose and glucose, in milk in the form of lactose, and in maltose, as a result of the breakdown of starches by bacteria and salivary enzymes (Hillson 2002: 278). These sugars formed part of the diet of Mesolithic hunter-gatherers, but in the following periods, maltose would have become more common in the diet as a result of the introduction of cereals during the Neolithic period. The exploitation of Honeybees, evidenced by beeswax residue on Neolithic pottery, indeed some from southern Britain (Roffet-Salque *et al*. 2015: 8), may have led to an increased intake of honey during this time also. Sucrose is present in plants, but is found in greater concentrations in sugar cane, which was not imported into Britain until after this time, causing a major increase in the frequency of dental caries (Moore and Corbett 1971: 166). Indeed, sucrose has a particularly dramatic and long lasting effect on plaque fluid PH, and is seen as the major contributor to dental caries today (Hillson 2002: 278).

The frequency of dental caries reported for the Neolithic period by Roberts and Cox (2003: 69), who collated reports from 24 sites, was 3.3% TPR (73/2208), and Brothwell and Blake (1966: 60) presented a figure of 3.12% (36/1151) from data collected from Fussell's Lodge long barrow and other unspecified Neolithic sites. Both of these figures reflect the relatively low intake of sugars from this period. Nine of the 42 sites analysed for the present study had evidence of dental caries, and these were present on 15 teeth (Table 9.3). The human remains from the remaining 33 sites did not show any evidence of dental caries, and the TPR will be shown overleaf to reflect this.

Table 9.3: Sites with evidence of dental caries

SITE	MNI	MALE	FEMALE	# TEETH EXAMINED	# TEETH AFFECTED	TPR%
Belas Knap	19	✓		120	1	0.8%
Bown Hill	3			12	1	8.3%
Handley 27	1	✓		18	2	11%
Hazleton North	41			441	3	0.7%
Millbarrow	8			68	2	2.9%
Norton Bavant	12		✓	37	1	2.7%
Randwick	3			13	3	23%
Tilshead Old Ditch	1		✓	20	1	5%
West Kennet	42			295	1	0.3%
TOTAL	130	2	2	1024	15	1.5%

Three of the sites (Belas Knap, Norton Bavant, and Tilshead Old Ditch) had only one tooth out of the assemblage affected, in each case, on a tooth in the mandible that was in occlusion (left 3rd molar, left 1st molar, and left 2nd premolar respectively). The caries affecting the individual at West Kennet was present on an occluded left 2nd maxillary molar, and the one case of dental caries at Bown Hill was present on a loose tooth (mandibular 2nd molar, unsided). Handley 27 is a single inhumation, with two teeth affected in the mandible (right 1st molar, and right 2nd premolar). The remaining three sites (Hazleton North, Millbarrow, and Randwick) had three, two and three cases respectively of dental caries on loose teeth. The three affected teeth from Hazleton North were all molars but could be all from the same individual (two mandibular molars, one of them a 2nd molar, and a maxillary right 3rd molar). Similarly, the two affected teeth from Millbarrow were both molars and may be from the same person (right mandibular 1st molar, and a mandibular 1st molar, unsided). However, the three affected teeth from Randwick were two adult molars (one a 3rd unsided maxillary molar, and a 2nd mandibular molar, unsided), and a deciduous mandibular 2nd molar, which are very unlikely to have come from the same individual. Therefore, at least two individuals from Randwick suffered from dental caries. Together, a total of ten individuals (two males, two females, and six individuals of unknown sex) were affected by dental caries in this study, giving a CPR of 5.2% (10/192).

There was no evidence of dental caries on any of the teeth in the remaining 33 sites, and when all of the teeth examined in the study are taken into account, the overall TPR is 0.7% (15/2111) (Table 9.1), a figure much lower than stated in the previous studies. However, when the sex of those affected with caries is taken into account, the TPR is amended to 0.3% for males (2/585 teeth) and 0.5% for females (2/384 teeth).

Crown/ Occlusal Surface Caries

This category of carious lesion is the most common and is found on the molars and premolars, the topography of the teeth facilitating the retention of food particles (Ortner 2003: 591; Langsjoen 2011: 403). Nine of the 15 teeth affected by dental caries in this study are of this type: three teeth have caries on the buccal side of the molar (Belas Knap, Norton Bavant and Randwick), and six have caries on the occlusal surface of the crown, ranging in size from a small spot (West Kennet), to large cavities at Hazleton North long barrow (Figure 9.2).

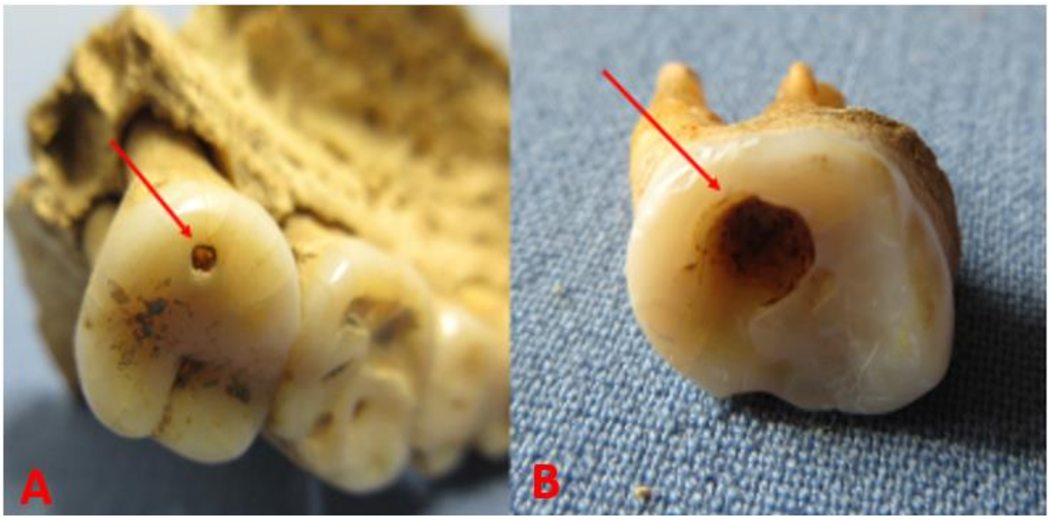


Figure 9.2: Occlusal dental caries: A- on 2nd maxillary molar (West Kennet). B - On 3rd maxillary molar (Hazleton North).

Interproximal Caries

Interproximal caries develop in the spaces between teeth, either where the adjacent tooth is missing, or where there has been some alveolar resorption surrounding the tooth, and a small gap has opened (Ortner 2003: 592). All of the dentition can be affected by this type of caries, and three examples of this cavity were found at Handley 27, Millbarrow, and Tilshead Old Ditch (Figure 9.3) and Figure 9.4 for another example.

Figure 9.3: Mandible from Tilshead Old Ditch, with interproximal caries on the left 2nd premolar.

Root Caries

Root caries develop on exposed root surfaces, either at the CEJ (cement-enamel junction) where the gingiva meets the tooth, or below it, and are commonly found on the buccal side of the dentition (Hillson 2002: 275). The bacteria demineralise the area and invade the dentin, eventually spreading circumferentially (Langsjoen 2011: 404). Two sites in the current study had examples of this type of caries: Hazleton North (two mandibular molars), and Handley 27 (mandibular first molar), which is a good example of the circumferential nature of root caries (Figure 9.4). Table 9.4 summarises the teeth affected by carious lesions, and the location on the affected tooth.

Figure 9.4: Mandible from Handley 27 with root cavity on 1st molar (arrow) and interproximal caries on 2nd premolar (circled).

Table 9.4: Summary of the teeth affected with carious lesions and the location.

SITE	TOOTH	MANDIBULAR	MAXILLARY	LOCATION CARIES	# INDIVIDUALS AFFECTED
Belas Knap	**M3**	✓		**Crown, buccal**	**1**
Bown Hill	**M2**	✓		**Crown, occlusal**	**1**
Handley 27	**Right M1** **Right P4**	✓ ✓		**Root, buccal** **Interproximal**	**1**
Hazleton North	**Molar** **M2** **Right M3**	✓ ✓	✓	**Root** **Root** **Crown, occlusal**	**1**
Millbarrow	**Right M1** **M1**	✓ ✓		**?** **Crown, buccal**	**1**
Norton Bavant	**Left M1**	✓		**Crown, buccal**	**1**
Randwick	**M2** **M3**	✓	✓	**Crown, occlusal** **Crown, occlusal**	**2**

	M2 (dec)	✓		Crown, buccal	
Tilshead Old Ditch	Left P4	✓		Interproximal	1
West Kennet	Left M2		✓	Crown, occlusal	1

9.3.2. Dental Abscess

The development of dental abscesses can occur in a number of ways: through trauma, attrition, or dental caries. If dental caries has formed on a tooth and the pulp cavity has been subsequently exposed, bacteria can enter, causing inflammation, and a build-up of pus (dead cells and bacteria) accumulates. Eventually, the pressure in the jaw becomes so great that a hole forms to allow the pus to escape (Dias and Tayles 1997: 551) (Figure 9.5).

Roberts and Cox (2003: 69) report a TPR of 3.8% (83/2158) for dental abscesses in the Neolithic period and Brothwell and Blake (1966: 60) report a TPR of 2.62%. Analysis of the dentition for the 42 sites in this study revealed that 12 assemblages had evidence of abscesses, which affected 61 sockets and at least 28 people (CPR 14.6%, 28/192) (Table 9.5). In agreement with Roberts and Cox (2003: 69), this study has found that more male individuals than females were affected – eight males and eight probable males versus two females and one probable female (plus seven undetermined for sex and two children). However, the overall TPR is lower than that quoted by the above authors, at 2% (61/3083). When the TPR is calculated for sex, 13 of the affected sockets belonged to males (1.4%, 13/905), 15 to probable males (4.1%, 15/366), four to females (0.6%, 4/684), five to probable females (1.5%, 5/324), 19 to unsexed individuals (3.4%, 19/562), and five to children (2%, 5/242).

Table 9.5: Sites with number of abscesses and number of individuals affected.

SITE	# Sockets	# Sockets Affected	# Individuals Affected	Sex	TPR%
Avening	31	0	0		0
Avenis (Smart's Farm)	30	0	0		0
Belas Knap	302	0	0		0
Bown Hill (Woodchester)	26	0	0		0
Bratton Camp	32	0	0		0
Broadsands	20	1	1	UND	5%

Chestnuts	0	0	0		0
Figheldean Down (31)	15	0	0		0
Fittleton Down (5)	12	0	0		0
Fromefield	31	0	0		0
Fyfield (Giants Grave)	55	2	1	M	3.6%
Gatcombe Lodge	32	0	0		0
Giant's Hills (Skendleby I)	62	0	0		0
Haddenham	38	1	1	UND	2.6%
Handley 26	16	0	0		0
Handley 27	28	0	0		0
Hazleton North	450	32	11	6 M? 1 M 1 F? 1 UN 2 Child	7.1%
Hetty Pegler's Tump (Uley)	79	9	4	1 M 1 M? 2 UND	11.4%
Horton Down (Bishops Cannings 91)	5	0	0		0
Imber (Bowls Barrow)	57	0	0		0
Jackbarrow	44	0	0		0
Kings Playdown (Heddington 3)	31	0	0		0
Lamborough Banks (Ablington)	0	0	0		0
Lanhill	115	5	2	2 M	4.3%
Littleton Drew (Lugbury)	137	1	1	1 M	0.7%
Luckington (Giants Cave)	63	0	0		0
Millbarrow	21	0	0		0
Netheravon Down (6)	27	0	0		0
Norton Bavant	42	0	0		0
Nympsfield	97	3	2	2 UND	3.1%
Oldbury Hill	30	1	1	F	3.3%
Randwick	22	0	0		0
Rodmarton	126	0	0		0
Stonehenge (Amesbury 14)	13	0	0		0
Stoney Littleton	0	0	0		0
Tilshead East (7)	38	0	0		0

Tilshead Lodge	41	0	0		0
Tilshead Old Ditch	28	3	1	F	10.7%
West Tump (Cranham)	0	0	0		0
Winterbourne Monkton	242	2	2	1 M 1 M?	0.8%
Wor Barrow	142	1	1	M	0.7%
West Kennet	503	0	0		0
TOTAL	3083	61	28		2%

Figure 9.5: Mandible from Winterbourne Monkton with abscess in the socket of the first molar, surrounded by reactive new bone.

The majority of sites in the current study exhibited no evidence of dental abscesses present within the population. However, of the 12 that did (28.5%, 12/42), most of the affected individuals had only one or two abscesses (including two children from Hazleton North long barrow), except for an individual at Lanhill long barrow, who had two abscesses in the mandible and one in the maxilla, and an inhumation from Tilshead Old Ditch, who had one abscess in the mandible, and two in the maxilla. However, one individual from Hetty Pegler's Tump (Uley long barrow) had five abscesses on the anterior and right side of the maxilla (left lateral incisor; right central and lateral incisors; and right first and second premolars), and a further abscess, or oro-antral fistula in the maxillary sinus, where a maxillary molar has perforated the surface of the sinus (Figure 9.6). (N.B. an oro-antral fistula is also present on the maxilla of a female individual from Winterbourne Monkton). It is unclear whether the individual from Uley long barrow suffered from dental caries, as the remaining four teeth show no evidence of this. They are however, heavily worn down with the dentine fully exposed and this may be the path through which bacteria entered the maxilla. The oro-antral fistula within the maxillary sinus may have led to maxillary sinusitis (Boocock *et al*. 1995: 484), a condition that is characterised by spicules of new bone and pitting (Figure 9.6, right), and which can lead to complications such as meningitis (Diaz and Bamberger, 1995), which in a pre-antibiotic era would probably have been fatal.

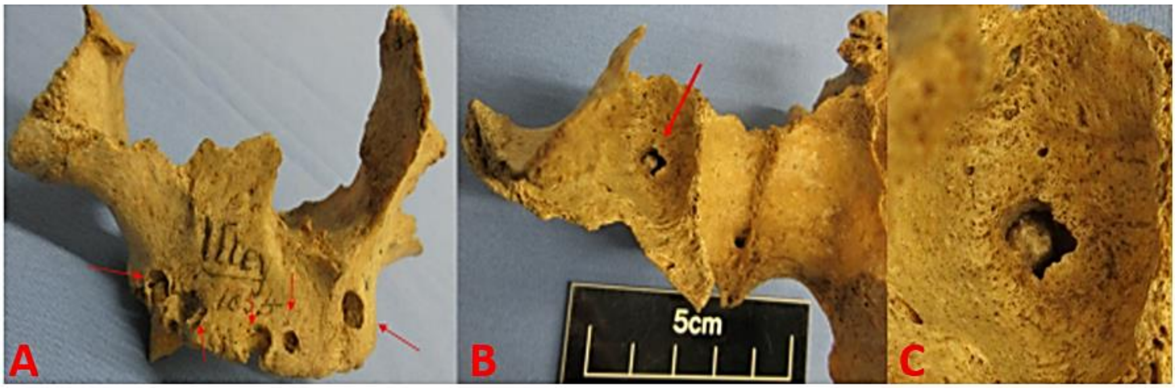


Figure 9.6: Maxilla from Hetty Pegler's Tump (Uley long barrow). A - Five abscesses on the anterior surface. B - An oro-antral fistula in the sinus. C – Detail.

9.4. Degenerative Disease

9.4.1 Periodontal Disease

Periodontal disease is caused by inflammation of the soft tissues (gingivae and mucosa) surrounding the tooth, which forms a periodontal pocket full of bacteria (Waldron 2009: 240). Eventually, the alveolar bone of the mandible or maxilla becomes infected, and resorption occurs, increasing the gap between the cemento-enamel junction and the bone (Figure 9.7), together with the loss of the periodontal ligament, until the tooth loosens and falls out (Langsjoen 2011: 401). Periodontal disease is related to age, and is very common in adults over the age of 30 (Hillson 2002: 267), and can be linked to serious and potentially fatal diseases such as cardiovascular disease, diabetes and pulmonary disease (Waldron 2009: 240). Roberts and Cox (2003: 70) report a CPR of 14% (13/93) of individuals affected in the Neolithic period, but the present study found that only 17 individuals from the 42 sites were affected, which is a CPR of 8.9% (17/192) (Table 9.6). More males (four males, plus six probable males) than females (five females, plus two probable females) suffered from periodontal disease, but a TPR was not calculated for this disease, as it was only recorded as present or absent in individuals in the assemblage. However, when the CPR is calculated by sex, the figures rise to 17.5% (10/57) for males and probable males, and 15.9% (7/44) for females and probable females. Increasing age was a factor with those with the condition (Table 9.7) and 29% (5/17) of those affected came from the same site, Hazleton North long barrow.

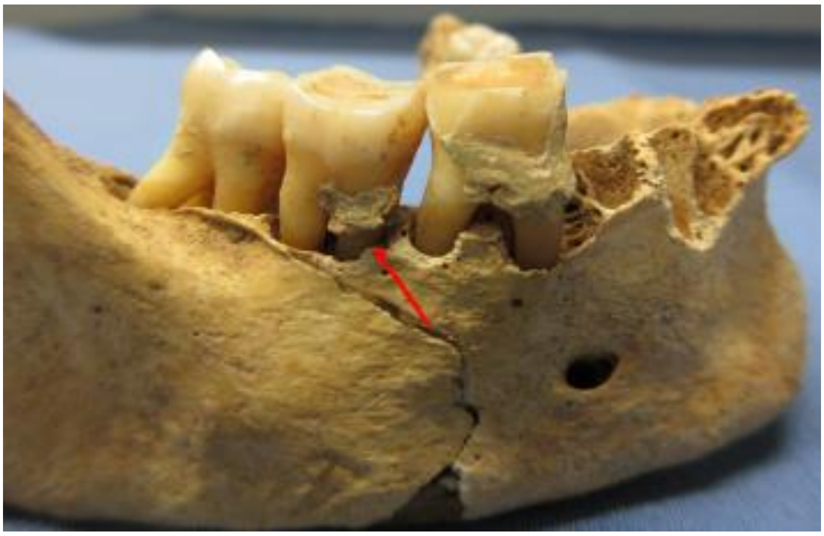


Figure 9.7: Mandible from West Kennet long barrow with periodontal disease and sub-gingival calculus (red arrow).

Table 9.6: Periodontal disease at the sites studied and number of individuals affected.

SITE	MNI	# of Individuals with Dentition Present	# Individuals Affected	Male	Female	CPR%
Avening	3	3	0	0	0	0
Avenis (Smart's Farm)	5	3	0	0	0	0
Belas Knap	19	15	3	1	2	20%
Bown Hill (Woodchester)	3	3	0	0	0	0
Bratton Camp	1	1	0	0	0	0
Broadsands	6	2	0	0	0	0
Chestnuts	7	0	0	0	0	0
Figheldean Down (31)	1	1	0	0	0	0
Fittleton Down (5)	1	1	0	0	0	0
Fromefield	18	4	0	0	0	0
Fyfield (Giants Grave)	2	2	0	0	0	0
Gatcombe Lodge	1	1	0	0	0	0
Giant's Hills (Skendleby I)	6	3	0	0	0	0

Haddenham	5	4	0	0	0	0
Handley 26	1	1	1	0	1	100%
Handley 27	1	1	0	0	0	0
Hazleton North	41	30	5	4?	1?	16.6%
Hetty Pegler's Tump (Uley)	5	4	1	1	0	25%
Horton Down (Bishops Cannings 91)	1	0	0	0	0	0
Imber (Bowls Barrow)	5	3	0	0	0	0
Jackbarrow	3	3	0	0	0	0
Kings Playdown (Heddington 3)	1	1	0	0	0	0
Lamborough Banks (Ablington)	1	0	0	0	0	0
Lanhill	8	6	1	1	0	16.6%
Littleton Drew (Lugbury)	12	8	1	1?	0	12.5%
Luckington (Giants Cave)	11	4	0	0	0	0
Millbarrow	8	4	0	0	0	0
Netheravon Down (6)	2	2	0	0	0	0
Norton Bavant	12	3	0	0	0	0
Nympsfield	9	7	0	0	0	0
Oldbury Hill	3	2	0	0	0	0
Randwick	3	2	0	0	0	0
Rodmarton	12	12	0	0	0	0
Stonehenge (Amesbury 14)	3	1	0	0	0	0
Stoney Littleton	2	0	0	0	0	0
Tilshead East (7)	8	3	0	0	0	0
Tilshead Lodge	2	2	1	1	0	50%
Tilshead Old Ditch	1	1	1	0	1	100%
West Tump (Cranham)	1	0	0	0	0	0
Winterbourne Monkton	22	15	0	0	0	0
Wor Barrow	7	5	1	0	1?	20%
West Kennet	42	29	2	1?	1	6.7%
TOTAL	305	192	17	4 + 6?	5 + 2?	8.9%

Table 9.7: Individuals with periodontal disease by age and sex.

Site	Age	Sex
Belas Knap EU.1.5.08	39-56	F
Belas Knap EU.1.5.17	25-35	F
Belas Knap EU.1.5.22	33-45	M
Handley 26	33-45	F
Hazleton North # 8754/11456	45+	F?
Hazleton North # 3831	45+	M?
Hazleton North # 7386	45+	M?
Hazleton North # 3793	25-35	M?
Hazleton North # 4788	45+	M?
Hetty Pegler's Tump (Uley) # 78/1965	33-45	M
Lanhill EU.1.5.104	39-56	M
Littleton Drew EU.1.5.155	25-35	M?
Tilshead Lodge EU.1.5.85	25-35	M
Tilshead Old Ditch EU.1.5.87	48-56	F
West Kennet EU.1.5.143	25-35	F
West KennetEU.1.5.62	25-35	M?
Wor Barrow Skeleton # 5	40-60	F?

9.3.2. Calculus

Calculus is dental plaque that has become mineralised, and is principally composed of calcium phosphate (Waldron 2009: 240). This deposit accumulates on the teeth of individuals who consume a high protein diet, or one that is rich in carbohydrates which favour an alkaline oral environment (Lieverse 1999: 219). The areas of the mouth that seem to be most affected by dental calculus are the ones that are nearest to the salivary glands – the lingual surfaces of the anterior teeth, and the buccal surfaces of the molars (Hillson 2002: 255). There are two forms of dental calculus: supragingival and subgingival calculus. Supragingival calculus forms on the crown of the tooth, either just at the margin of the tooth at the CEJ, or in severe cases, it can extend higher up the tooth, forming a crust of cream or brown coloured material (Hillson 2002: 256), (Figure 9.8).

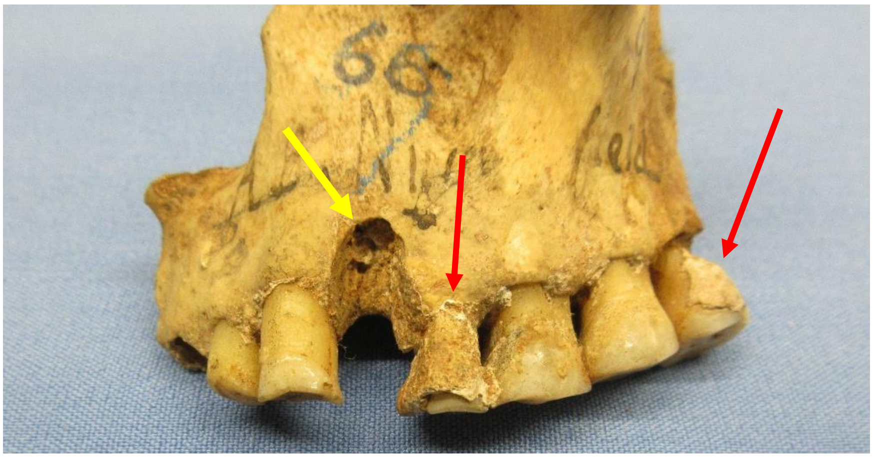


Figure 9.8: Partial maxilla from an individual from Nympsfield long barrow with supra-gingival dental calculus (red arrows) and dental abscess (yellow arrow).

The other form of dental calculus is subgingival calculus, which forms below the CEJ on the roots of the tooth, once they have become exposed through periodontal disease (Hillson 2008: 312) (Figure 9.7). Whilst signifying a disregard for dental hygiene, dental calculus has also been a very useful resource for studying palaeoenvironments and diet (Dobney and Brothwell, 1986), and ancient DNA and disease (Preus *et al*., 2011; De La Feunte *et al*., 2012; Warrinner *et al*., 2014).

The analysis of the dentition for the present study found that of the 192 individuals represented, 85 (CPR 44.2%) had calculus deposits on their teeth (Table 9.8). Twelve sites had a prevalence rate of 100% and 15 had a rate of 0%. There were fairly equal numbers of both sexes with this condition – 25 males and 12 possible males, compared to 25 females, and six possible females, and 17 unsexed individuals. It is not possible to give a TPR for calculus, as it was only recorded as present or absent in individuals. However, when the CPR is calculated by sex, the rates rise to 65% (37/57) for males and probable males, and 70.5% (31/44) for females and probable females. Roberts and Cox (2003: 69) report a CPR of 11% (17/159) for the Neolithic period, based on reported values from nine sites. It is unclear why the figures presented by Roberts and Cox (2003: 69) differ so widely from those of this study, but it may be due to the possibility that calcified dental plaque can chip and fall off during burial, excavation, washing and curation, and can therefore skew the results. In addition, when the antiquity of the excavation of the majority of Neolithic sites is taken into consideration, these figures may represent only a minimal prevalence.

Table 9.8: Calculus at the sites, and number of individuals affected.

SITE	MNI	# Individuals with a Dentition Present	# Individuals Affected	Male	Female	UND	CPR%
Avening	3	3	0	0	0	0	0
Avenis (Smart's Farm)	5	3	0	0	0	0	0
Belas Knap	19	15	5	1 2?	1 1?	0	33.3%
Bown Hill (Woodchester)	3	3	3	0	1?	2	100%
Bratton Camp	1	1	1	0	1	0	100%
Broadsands	6	2	0	0	0	0	0
Chestnuts	7	0	0	0	0	0	0
Figheldean Down (31)	1	1	0	0	0	0	0
Fittleton Down (5)	1	1	1	1?	0	0	100%
Fromefield	18	4	2	0	0	2	50%
Fyfield (Giants Grave)	2	2	2	2	0	0	100%
Gatcombe Lodge	1	1	0	0	0	0	0
Giant's Hills (Skendleby I)	6	3	2	2	0	0	66.6%
Haddenham	5	4	0	0	0	0	0
Handley 26	1	1	1	0	1	0	100%
Handley 27	1	1	1	1	0	0	100%
Hazleton North	41	30	13	2 6?	1?	4	43.3%
Hetty Pegler's Tump (Uley)	5	4	3	1 1?	1	0	75%
Horton Down (Bishops Cannings 91)	1	0	0	0	0	0	0
Imber (Bowls Barrow)	5	3	2	0	1 1?	0	66.6%
Jackbarrow	3	3	1	1	0	0	33.3%
Kings Playdown (Heddington 3)	1	1	0	0	0	0	0
Lamborough Banks (Ablington)	1	0	0	0	0	0	0
Lanhill	8	6	2	1	1?	0	33.3%
Littleton Drew (Lugbury)	12	8	8	2	3	3	100%
Luckington (Giants Cave)	11	4	3	0	1	2	75%

Millbarrow	**8**	**4**	**2**	**0**	**0**	**2**	**50%**
Netheravon Down (6)	**2**	**2**	**0**	**0**	**0**	**0**	**0**
Norton Bavant	**12**	**3**	**3**	**1**	**2**	**0**	**100%**
Nympsfield	**9**	**7**	**2**	**0**	**1**	**1**	**28.5%**
Oldbury Hill	**3**	**2**	**0**	**0**	**0**	**0**	**0**
Randwick	**3**	**2**	**2**	**2**	**0**	**0**	**100%**
Rodmarton	**12**	**12**	**2**	**0**	**1**	**1**	**16.7%**
Stonehenge (Amesbury 14)	**3**	**1**	**1**	**0**	**1**	**0**	**100%**
Stoney Littleton	**2**	**0**	**0**	**0**	**0**	**0**	**0**
Tilshead East (7)	**8**	**3**	**0**	**0**	**0**	**0**	**0**
Tilshead Lodge	**2**	**2**	**1**	**1**	**0**	**0**	**50%**
Tilshead Old Ditch	**1**	**1**	**1**	**0**	**1**	**0**	**100%**
West Tump (Cranham)	**1**	**0**	**0**	**0**	**0**	**0**	**0**
Winterbourne Monkton	**22**	**15**	**8**	**2 2?**	**4**	**0**	**53.3%**
Wor Barrow	**7**	**5**	**5**	**3**	**2**	**0**	**100%**
West Kennet	**42**	**29**	**8**	**3**	**4 1?**	**0**	**27.6%**
TOTAL	**305**	**192**	**85**	**25 12?**	**25 6?**	**17**	**44.2%**

9.3.3 Ante-Mortem Tooth Loss

Ante-mortem tooth loss may be caused in a variety of ways: trauma, extraction, diseases such as scurvy, or by far the most common cause, periodontal disease (Hillson 2002: 266). The loss of a tooth before death can be recognised within the jaws by remodelled alveolar bone – the degree of resorption and infilling of the socket, indicates the interval of time before death occurred (Figure 9.9). Therefore, pristine but empty tooth sockets, indicate that the tooth loss probably occurred post mortem. Ante-mortem tooth loss affects quality of life, in as much as eating and chewing would be very difficult, if not painful (Waldron 2009: 239). In addition, the risk of malnutrition is very high (Musacchio *et al.* 2007: 84).

Roberts and Cox (2003: 69) state that ante-mortem tooth loss in the Neolithic period is 6.1% TPR (87/1428), with more males being affected than females. Blake and Brothwell (1966: 60) report of TPR of 10.83% but do not record the difference in the prevalence between males and females. The results of the present study show a TPR of 6.4%, with 197 out of 3083 sockets affected, and at least 41 individuals (CPR 21.3% 41/192) (Table 9.9). There are slightly more males than females affected (eleven males and seven possible males, versus nine females and six possible females, plus eight unsexed individuals). However, when the number of affected sockets per individual are counted, it is apparent that females have lost more teeth ante-mortem than the males: 65 (9.5% 65/684 sockets) and 29 (9%, 29/324 sockets) teeth for females and probable females respectively, and 27 (3%, 27/905 sockets) teeth lost for males, with 53 (14.5%, 53/366 sockets) for probable males, plus 23 (4%, 23/562 sockets) unsexed.

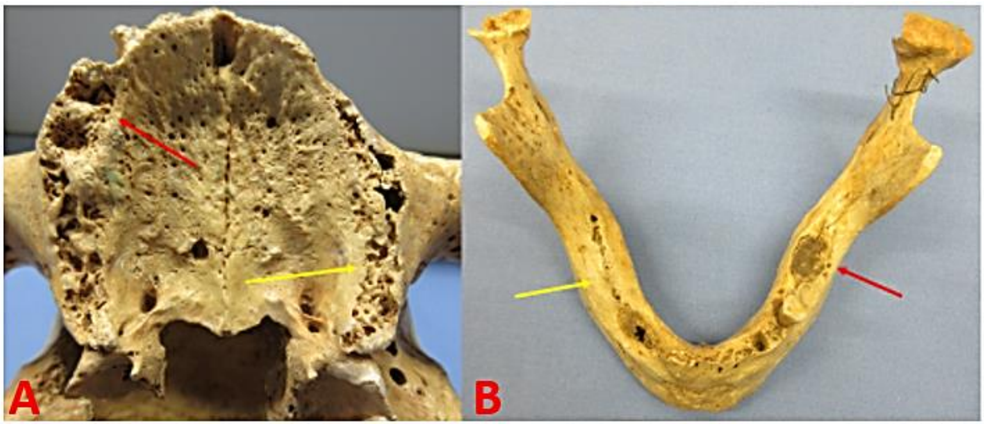


Figure 9.9: A - Maxilla and B - mandible from elderly female individual from Lanhill long barrow. Arrows indicate different degrees of resorption of the alveolar bone: yellow arrows indicate that the bone is nearly fully resorbed, but the red arrows indicate a later episode of tooth loss.

Table 9.9: Ante-mortem tooth loss at the sites, with numbers of sockets and individuals.

SITE	MNI	# Sockets	# Sockets Affected	Male	Female	UND	TPR%
Avening	3	31	4	0	1?	0	12.9%
Avenis (Smart's Farm)	5	30	6	0	0	1	20%
Belas Knap	19	302	14	3	1	0	4.6%
Bown Hill (Woodchester)	3	26	1	0	1?	0	3.9%
Bratton Camp	1	32	0	0	0	0	0
Broadsands	6	20	0	0	0	0	0
Chestnuts	7	0	0	0	0	0	0
Figheldean Down (31)	1	15	0	0	0	0	0
Fittleton Down (5)	1	12	0	0	0	0	0
Fromefield	18	31	0	0	0	0	0

Fyfield (Giants Grave)	2	55	3	1	0	0	5.5%
Gatcombe Lodge	1	32	0	0	0	0	0
Giant's Hills (Skendleby I)	6	62	0	0	0	0	0
Haddenham	5	38	1	0	0	1	2.63%
Handley 26	1	16	0	0	0	0	0
Handley 27	1	28	3	1	0	0	10.7%
Hazleton North	41	450	75	2, 6?	3?	1	16.6%
Hetty Pegler's Tump (Uley)	5	79	0	0	0	0	0
Horton Down (Bishops Cannings 91)	1	5	0	0	0	0	0
Imber (Bowls Barrow)	5	57	0	0	0	0	0
Jackbarrow	3	44	4	0	1	0	9.09%
Kings Playdown (Heddington 3)	1	31	0	0	0	0	0
Lamborough Banks (Ablington)	1	0	0	0	0	0	0
Lanhill	8	115	36	2	1	0	2.6%
Littleton Drew (Lugbury)	12	137	4	1?	1	0	2.9%
Luckington (Giants Cave)	11	63	1	0	0	1	1.6%
Millbarrow	8	21	0	0	0	0	0
Netheravon Down (6)	2	27	0	0	0	0	0
Norton Bavant	12	42	0	0	0	0	0
Nympsfield	9	97	3	0	1?	0	3.1%
Oldbury Hill	3	30	6	0	1	0	20%
Randwick	3	6	0	0	0	0	0
Rodmarton	12	126	13	0	2	1	10.3%
Stonehenge (Amesbury 14)	3	13	0	0	0	0	0
Stoney Littleton	2	0	0	0	0	0	0
Tilshead East (7)	8	38	0	0	0	0	0
Tilshead Lodge	2	41	0	0	0	0	0
Tilshead Old Ditch	1	28	2	0	1	0	7.1%
West Tump (Cranham)	1	0	0	0	0	0	0
Winterbourne Monkton	22	242	1	1	0	0	0.4%
Wor Barrow	7	142	0	0	0	0	0
West Kennet	42	503	20	1	1	3	3.8%
TOTAL	305	3083	197	11 7?	9, 6?	8	6.4%

As Table 9.9 shows, Hazleton North long barrow has the highest prevalence rate of ante-mortem tooth loss at 16.6% (75/450). This assemblage also contained a high percentage of individuals affected by periodontal disease (29%, 5/17), and in fact, these two conditions may be related. The majority of the affected individuals from the site with ante-mortem tooth loss were aged over 25 years at death (Table 9.10) and all of those affected, except for #7474 and #10213, had ante-mortem tooth loss in the posterior dentition, which is probably related to severe dental wear.

Table 9.10: Individuals with ante-mortem tooth loss.

Site	Sex	Age	Associated Dental Disease	Dental Wear
Avening # 7	F?	Old	Porosity	Edentulous
Avenis # 1950:279	UND	Old		Edentulous
Belas Knap EU.1.5.04	M	45-56		High
Belas Knap EU.1.5.21	M	?		Severe (only 1 tooth extant)
Belas Knap EU.1.5.23	F	Old		Mostly edentulous (some teeth missing)
Bown Hill EU.1.5.138	F?	Old	Calculus	High
Fyfield EU.1.5.82	M	33-45	Calculus, abscess x 2	Severe
Haddenham Skeleton F	UND	?	Abscess	Severe (only 1 tooth extant)
Handley 27	M	40-60	Caries, calculus	Moderate
Hazleton North Skeleton A	M	23-57		Severe (only 1 tooth extant)
Hazleton North Skeleton 1	M	40-45	Abscess, calculus, attrition	Moderate/high
Hazleton North Skeleton B	M?	Old	Attrition	Severe (only 1 tooth extant)
Hazleton North # 3596	M?	45+	Abscess, calculus, attrition	Severe
Hazleton North # 3831	M?	45+	Abscess, calculus, periodontal, attrition	High
Hazleton North # 7386	M?	45+	Abscess, calculus, periodontal, attrition	Severe
Hazleton North # 4041/4045	M?	45+	Abscess, calculus, attrition	Severe
Hazleton North # 3787/4806	M?	33-45	Abscess, calculus, attrition	Severe
Hazleton North # 10213	F?	25-35	Attrition	High
Hazleton North # 8754	F?	45+	Abscess, calculus, periodontal, attrition	Severe
Hazleton North # 9982	F?	45+		Edentulous
Hazleton North # 7474	UND	?	Calculus	Severe (only 1 tooth extant)

Jackbarrow # 2	F	Old		Severe
Lanhill EU.1.5.104	M	60+	Abscess, periodontal	Severe
Lanhill EU.1.5.105	F	50+		Severe (only 1 tooth extant)
Lanhill EU.1.5.109	M	25-35		Moderate
Littleton Drew EU.1.5.51	F	25-35		High
Littleton Drew EU.1.5.55	M?	25-35		High
Luckington GC/D/1	UND	Old		Edentulous
Nympsfield # 63	F?	Old		Edentulous
Oldbury Hill C8	F	45-55		Severe (only 1 tooth extant)
Rodmarton #76	F	45+		Severe
Rodmarton # 80	F	48-56	Calculus	High
Rodmarton XXX	UND	?		Severe
Tilshead Old Ditch EU.1.5.87	F	48-56	Caries, abscess, calculus	Severe
Winterbourne Monkton EU.1.5.30	M	?		Mostly edentulous (some teeth missing)
West Kennet EU.1.5.143	F	25-35	Calculus, periodontal	High
West Kennet SE chamber75	UND	?		Moderate
West Kennet NW chamber 15	UND	50+		Edentulous
West Kennet SW chamber 63	UND	50+		Edentulous
West Kennet SW chamber 69	M	33-45	Calculus	Moderate

9.4. Developmental Diseases

9.4.1 Enamel Hypoplasia

Enamel hypoplasia is the term given to defects in the enamel surface of teeth in individuals who have suffered a period of malnutrition or poor health during their early years, when the tooth crowns were developing (Langsjoen 2011: 405). Because the stress events linked to enamel hypoplasia are so severe, for instance, birth trauma (Seow 1991: 442), low birth weight (Fearne *et al*. 1990: 434), infection (Pindborg 1982: 126), starvation and systemic illnesses such as measles (Goodman and Rose 1991: 279), amelogenesis of tooth enamel is depressed, and a poorly formed layer is deposited as a result (Ogden 2008: 284). However, minor manifestations of the defect have been exhibited in apparently healthy modern children (Ogden 2008: 284). The development of the dentition occurs in a known sequence, therefore the age at which a child was affected by a stressful event can be gauged, by the tooth or teeth affected, and the position of the defect on the tooth (Goodman and Armelagos 1988: 937). The most common form of dental defect is of the pitted or linear type (Figure 9.10), which usually affects only the anterior teeth, and is formed within the first year of life, when the maxillary central incisors and mandibular canines are developing (Langsjoen 2011: 406). Plane-form hypoplasia is less common, and appears as an irregular border of normal enamel surrounding the thinner matrix. However, the rarest form of dental defect is labelled cuspal enamel hypoplasia, and is a combination of the plane-form defect, with additional scattered pitting covering the surface of the crown, affecting the normal cusp formation and adding extra smaller cusps (Ogden 2008: 287).

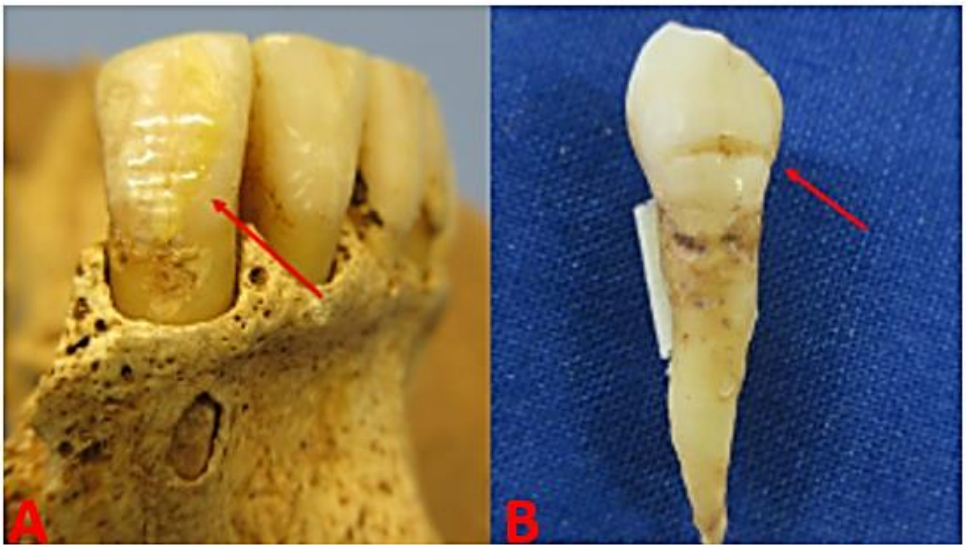


Figure 9.10: A - Mandible from Luckington long barrow with two linear defects. B - A loose tooth from Randwick long barrow with a deep linear defect.

The analysis of the 2111 teeth in the current study revealed that 46 were affected with enamel hypoplasia, all of the linear type. Four males and five possible males, seven females and one possible female, plus four unidentified adults were affected, giving a TPR of 2.2% (46/2111) (Table 9.11). When the TPR is calculated by sex, 21 (5.5%, 21/384 teeth) of the affected teeth belonged to females, three to probable females (2.6%, 3/116 teeth), five to males (1%, 5/585 teeth), ten (5.4%, 10/184 teeth) to probable males, and seven could not be assigned a sex (2.8%, 7/254 teeth). Roberts and Cox (2003: 67) give a figure of 2% for the Neolithic period for enamel hypoplasia, but the figure quoted is the crude prevalence rate, which when compared to this study is 10.9% (21/192). However, Power (1993: 11) gives a figure of 22.4% (30/134) of canine teeth affected from three unspecified Neolithic sites in Ireland, perhaps giving an insight into a widespread illness that affected many of the population, or a period of severe malnutrition that affected the community.

Table 9.11: Enamel hypoplasia at sites, with numbers affected and TPR%.

SITE	MNI	# Teeth	# Teeth Affected	Male	Female	UND	TPR%
Avening	3	28	0				0
Avenis (Smart's Farm)	5	12	3			1	25%
Belas Knap	19	120	4	2?			3.3%
Bown Hill (Woodchester)	3	12	1			1	8.3%
Bratton Camp	1	11	0				0
Broadsands	6	12	0				0
Chestnuts	7	0	0				0
Figheldean Down (31)	1	13	0				0
Fittleton Down (5)	1	10	0				0
Fromefield	18	71	0				0
Fyfield (Giants Grave)	2	34	0				0
Gatcombe Lodge	1	22	0				0
Giant's Hills (Skendleby I)	6	54	1	1			1.9%
Haddenham	5	12	0				0
Handley 26	1	29	0				0
Handley 27	1	18	0				0
Hazleton North	41	441	0				0
Hetty Pegler's Tump (Uley)	5	31	0				0
Horton Down (Bishops Cannings 91)	1	0	0				0
Imber (Bowls Barrow)	5	30	1		1		3.3%
Jackbarrow	3	20	0				0
Kings Playdown (Heddington 3)	1	26	0				0
Lamborough Banks (Ablington)	1	0	0				0
Lanhill	8	65	0				0
Littleton Drew (Lugbury)	12	82	6		1		7.3%
Luckington (Giants Cave)	11	58	5		1 1?		8.6%
Millbarrow	8	68	0				0
Netheravon Down (6)	2	22	0				0
Norton Bavant	12	37	0				0
Nympsfield	9	46	0				0

Oldbury Hill	**3**	**14**	**0**				**0**
Randwick	**3**	**13**	**3**			**2**	**23%**
Rodmarton	**12**	**59**	**0**				**0**
Stonehenge (Amesbury 14)	**3**	**8**	**0**				**0**
Stoney Littleton	**2**	**0**	**0**				**0**
Tilshead East (7)	**8**	**20**	**0**				**0**
Tilshead Lodge	**2**	**23**	**1**	**1**			**4.3%**
Tilshead Old Ditch	**1**	**20**	**2**		**1**		**10%**
West Tump (Cranham)	**1**	**0**	**0**				**0**
Winterbourne Monkton	**22**	**163**	**8**	**1 2?**	**1**		**4.9%**
Wor Barrow	**7**	**98**	**0**				**0**
West Kennet	**42**	**295**	**9**	**1 1?**	**1**		**3.1%**
TOTAL	**305**	**2111**	**46**	**4 5?**	**7 1?**	**4**	**2.2%**

The individual from Luckington long barrow featured in Figure 9.10 has two linear defects on the permanent mandibular right canine, representing two different episodes of illness or some other life-threatening scenario. When measured, the lines are 2.1mm and 3.8mm from the cemento-enamel junction. These measurements equate to serious episodes experienced at the ages of 4.7 years and 3.6 years respectively, based on a regression formula of: Age= - (.625 x Ht) + 6.0 (Goodman and Rose, 1990).

9.4.2. Supernumerary Teeth

Two individuals in the current study (CPR 1% 2/192) had supernumerary teeth (polydontia or polygenesis) of the maxilla (Hillson 2002: 114). In both cases, the individuals, one from Luckington long barrow, and the other from Lanhill long barrow, had an extra tooth tucked in behind the third molar on both sides (Figure 9.11). In both cases, the tooth is small and mal-formed. Polygenesis is not as common as agenesis and is usually found in the anterior teeth, rather than the molars (Lavelle and Moore 1973: 672).

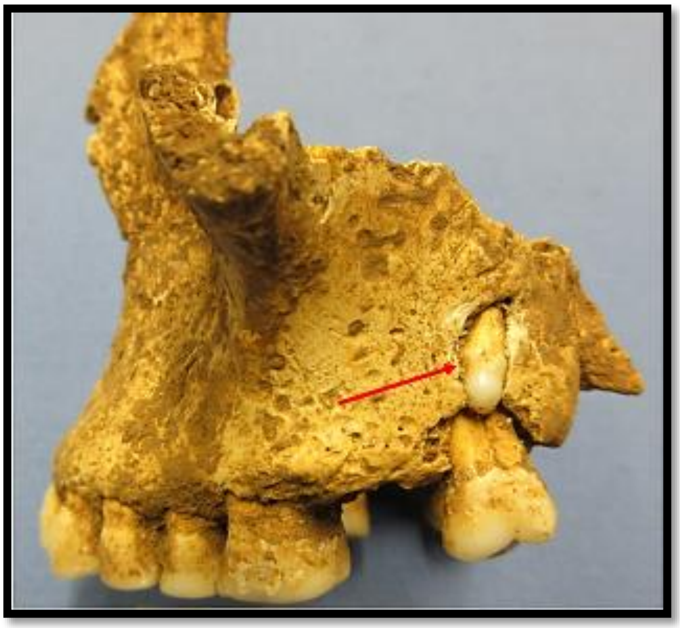


Figure 9.11: Polygenesis in an individual from Luckington long barrow.

9.5. Miscellaneous Conditions of the Teeth

9.5.1. Attrition

Dental attrition, that is, wear, is generally associated with old age and can be used to age skeletal remains. Attrition is an on-going process and is, “the natural result of masticatory stress upon the dentition in the course of both alimentary and technological activities” (Powell 1985: 308). When the teeth grind against each other during chewing and swallowing, the enamel is worn down, and if the pulp cavity becomes exposed, secondary dentine is produced to protect it (Ogden 2008:291). However, dental attrition predisposes an individual to periodontal disease, caries, dental abscesses and ante mortem disease (Langsjoen 2011: 399).

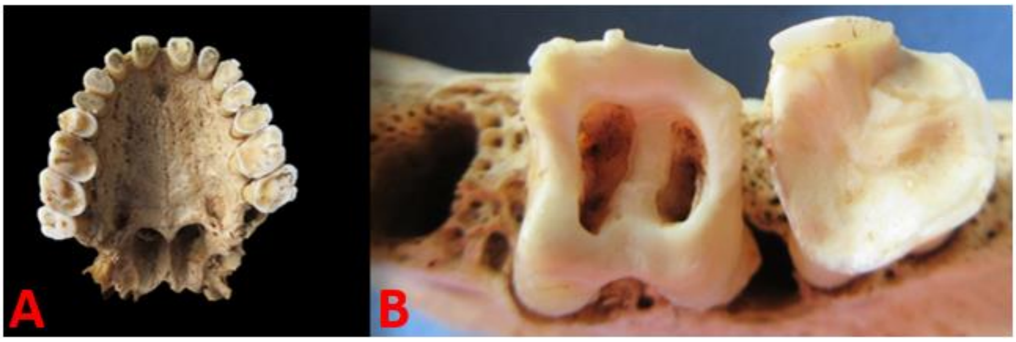


Figure 9.12: A - Maxillary dentition from an individual from Belas Knap long barrow, with attrition on all tooth surfaces. B - Mandible from Hazleton North with extreme attrition on the molars.

Attrition may occur on the occlusal surfaces of molars and premolars and on the biting surfaces of the incisors (Figure 9.12). Abrasion is a form of attrition, but is not caused by tooth on tooth action, but by the dentition coming into contact with objects that were held in the mouth, such as stone tools or hides (Hillson 2002: 231). In addition, eating foods, such as cereals, that were processed by grinding (on quern stones, for example) can introduce tiny abrasive particles into the mouth. Erosion is also a form of dental attrition, and is caused by chemical agents, such as acid found in fruit, eating away at the teeth (Featherstone and Lussi 2006: 68). The dentition can also be eroded by acid produced as gastric refluxate, which has a low pH of 2.0, causing the hydroxyapatite crystals in the enamel to dissolve, and is a phenomenom seen in individuals who suffer from bulimia, chronic vomiting during pregnancy, or those with GERD (gastroesophageal reflux disease) (Barron *et al*. 2003: 84-85). The resulting erosion takes the form of "cupping" lesions which are more common on the occlusal surfaces of the deciduous or permanent mandibular molars (Farahmand *et al*. 2013: 279; Barron *et al*. 2003: 85) (Figure 9.13).

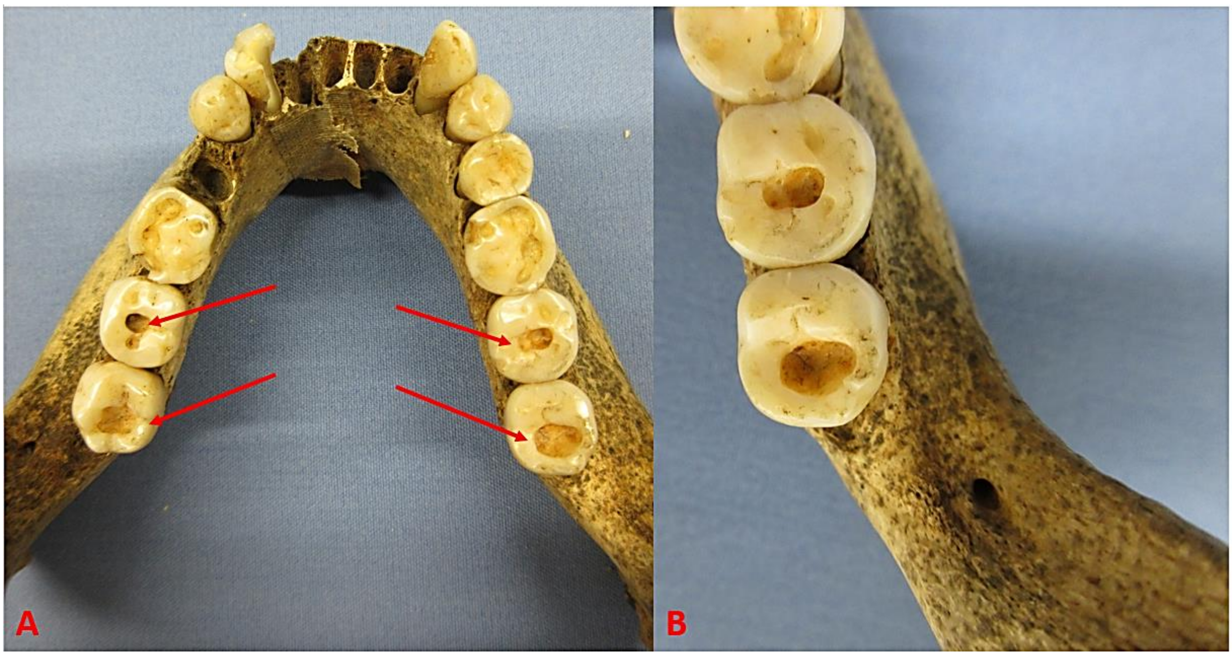


Figure 9.13: A – Adult male from Gatcombe Lodge long barrow (EU. 1.5.103) with erosion to the mandibular dentition caused by gastric acid reflux. B – Detail of left dentition.

The analysis of the available dentition for the current study found that 103 individuals from all sites suffered from severe attrition, giving a CPR of 53.6% (103/192). The lowest prevalence is found at Millbarrow, where 25% of the assemblage had attrition of the dentition (1/4), and the highest is 100% of the assemblage, found at 13 sites

(Figheldean Down, Fittleton Down, Gatcombe Lodge, Handley 26, Handley 27, Jackbarrow, Kings Playdown, Netheravon Down, Norton Bavant, Oldbury Hill, Randwick, Tilshead Lodge, and Tilshead Old Ditch), but in many cases, except for Tilshead Lodge, Netheravon Down, Norton Bavant, Oldbury Hill, Randwick and Jackbarrow, the assemblage consisted of only one individual (Table 9.12). Eleven of the 42 sites analysed did not contain any individuals who had attrition of the dentition (Bratton Camp, Chestnuts, Fromefield, Giant's Hills, Haddenham, Horton Down, Lamborough Banks, Stonehenge, Stoney Littleton, Tilshead East, and West Tump). However, in four cases, (Horton Down, Lamborough Banks, Stoney Littleton, and West Tump) this is due to the fact that there was no dentition available for study from these sites. There seems to be a bias in the sex of the individuals affected, with more males than females affected (30 males, and 22 possible males, versus 23 females and nine possible females). A TPR could not be calculated for this condition, as it was only recorded as absent or present in individuals.

Table 9.12: Attrition at sites and number of individuals affected.

SITE	MNI	# Individuals with Dentition Present	# Individuals affected	Male	Female	UND	CPR%
Avening	3	3	2	0	0	2	66.7%
Avenis (Smart's Farm)	5	3	2	0	0	2	66.7%
Belas Knap	19	15	6	2 1?	3	0	40%
Bown Hill (Woodchester)	3	3	1	0	1?	0	33.3%
Bratton Camp	1	1	0	0	0	0	0
Broadsands	6	2	1	0	1?	0	50%
Chestnuts	7	0	0	0	0	0	0
Figheldean Down (31)	1	1	1	0	0	1	100%
Fittleton Down (5)	1	1	1	1?	0	0	100%
Fromefield	18	4	0	0	0	0	0
Fyfield (Giants Grave)	2	2	1	1	0	0	50%
Gatcombe Lodge	1	1	1	1	0	0	100%
Giant's Hills (Skendleby I)	6	3	0	0	0	0	0
Haddenham	5	4	0	0	0	0	0
Handley 26	1	1	1	0	1	0	100%
Handley 27	1	1	1	1	0	0	100%
Hazleton North	41	30	16	2 9?	2?	3	53.3%
Hetty Pegler's Tump (Uley)	5	4	3	1 1?	1?	0	75%
Horton Down (Bishops Cannings 91)	1	0	0	0	0	0	0
Imber (Bowls Barrow)	5	3	1	0	1?	0	33.3%
Jackbarrow	3	3	3	1	2	0	100%
Kings Playdown (Heddington 3)	1	1	1	1	0	0	100%
Lamborough Banks (Ablington)	1	0	0	0	0	0	0
Lanhill	8	6	3	2	1	0	50%
Littleton Drew (Lugbury)	12	8	6	1 2?	1	2	75%
Luckington (Giants Cave)	11	4	2	0	1?	1	50%
Millbarrow	8	4	1	0	0	1	25%
Netheravon Down (6)	2	2	2	1	0	1	100%
Norton Bavant	12	3	3	1	2	0	100%

Nympsfield	9	7	5	2?	1	2	71.4%
Oldbury Hill	3	2	2	1?	1	0	100%
Randwick	3	2	2	2	0	0	100%
Rodmarton	12	12	7	0	2 2?	3	58.3%
Stonehenge (Amesbury 14)	3	1	0	0	0	0	0
Stoney Littleton	2	0	0	0	0	0	0
Tilshead East (7)	8	3	0	0	0	0	0
Tilshead Lodge	2	2	2	2	0	0	100%
Tilshead Old Ditch	1	1	1	0	1	0	100%
West Tump (Cranham)	1	0	0	0	0	0	0
Winterbourne Monkton	22	15	12	4 4?	4	0	80%
Wor Barrow	7	5	4	3	1	0	80%
West Kennet	42	29	9	4 1?	3	1	31%
TOTAL	305	192	103	30 22?	23 9?	19	53.6%

9.5.2. Cuspal Anomalies

Extra Cusps

Extra cusps on molars are not considered to be associated with disease but are a normal variant or non-metric trait. One individual aged between seven and nine years of age from Belas knap has an extra cusp on the lingual surface of the maxillary first permanent molar (Figure 9.14A) (CPR 0.52%, 1/192), and the single male inhumation from Handley 27 has a cusp of Carabelli on the upper right second molar (CPR 0.52%, 1/192), a location which is fairly uncommon because the first molar is the most common place for this trait (Hillson 2002: 91) (Figure 9.14B).

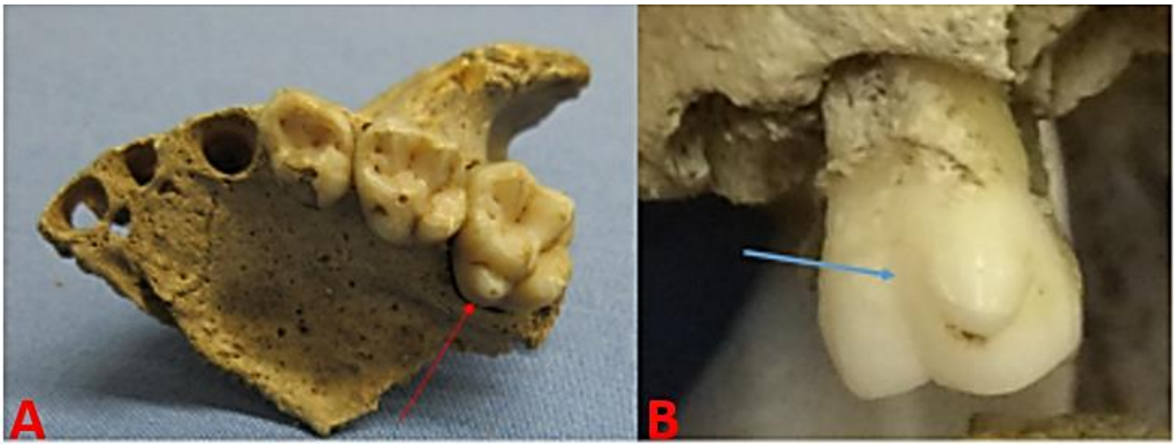


Figure 9.14: A - Extra cusps on the molars of a child from Belas Knap (red arrow) B - Handley 27, cusp of Carabelli (blue arrow).

Talon Cusp

The talon cusp, or dens evaginatus, is a relatively rare form of developmental tooth anomaly which projects from the CEJ in the permanent or deciduous dentition of the anterior teeth, either on the lingual surface or the buccal surface (Hattab and Hazza'a

2001: 263). The extra cusp can take the three forms: a prominent and clearly defined extra cusp that reaches at least halfway up the crown of the tooth (talon); an extra cusp that extends more than a millimetre but less than halfway up the tooth crown (semi-talon); or an enlarged or prominent cingula (trace-talon) (Hattab and Hazza'a 2001: 263-6). Talon cusps are thought to develop in the morphodifferentiation stage, as a result of out-folding of the enamel, or hyper productivity of the dental lamina (Hattab *et al*. 1995: 115). The prevalence for talon cusps in modern populations is only 0.06% to 7.7% (India and South America, respectively), and is most common in the permanent maxillary dentition (the lateral incisors particularly), with males more likely to be affected than females (Hattab and Hazza'a 2001: 263). Besides looking unsightly if positioned on the buccal surface of the tooth, talon cusps can cause a range of problems to the individual such as, occlusal interference, trauma to the adjacent facial tissues, and may become carious due to the extra fissures within the cusp (Hattab *et al.* 1995: 119). One immature individual in the current study (CPR 0.52% 1/192), from Hazleton North long barrow, exhibits this trait (Figure (9.15).

Figure 9.15: Talon cusp on a loose deciduous maxillary canine from Hazleton North long barrow.

Impacted Teeth

Impaction of the teeth simply means that a tooth has failed to erupt and has not occluded with a tooth in the opposing jaw, and is most commonly seen in the third mandibular molar (Hillson 2002: 113). Whilst most people with this condition do not suffer any ill effects, impacted molars can lead to odontic tumours and dentigerous cysts. Whilst most dentigerous cysts are benign (Langsjoen 2011: 408), they can sometimes cause complications, such as extensive bone destruction, resorption of adjacent tooth roots, neoplastic transformation of the lining and ameloblastoma formation (Regezi *et al.* 2017: 250).

Two female individuals (CPR 1.04% 2/192) in the current study had impacted third mandibular molars, one from Stonehenge (Amesbury 14) long barrow, and the other from Tilshead East (7) long barrow (Figure 9.16). However, neither individual suffered from the above complications.

Figure 9.16: Mandible from Tilshead East (7), with impacted third molars which have failed to erupt.

Dental Crowding

The development of the dentition is governed by genetic and environmental factors and is not reliant on the same factors that affect development of the maxilla and mandible, thereby sometimes creating a situation where there is inadequate space in the jaw for the teeth, resulting in dental crowding, a phenomenon that is more common in the mandible (Ortner 2003: 598). Only one individual in the current study was found to have dental crowding (1/192, CPR 0.52%), a mature adult male from Wor Barrow (Skeleton # 4) (Figure 9.17). This individual has crowding of the anterior teeth, but the posterior teeth are unaffected, as is the maxillary dentition.

Figure 9.17: A - Mandible from Wor Barrow # 4, with dental crowing to the anterior teeth. B – Detail.

9.6 Summary

Table 9.13 details the crude, and where possible, the true prevalence rates for all of the dental conditions discussed in this chapter.

Table 9.13: Summary of dental conditions and prevalence rates in this study.

DENTAL CONDITION	CPR%	TPR%
Caries	5.2%	0.3% Male 0.5% Female
Dental Abscess	14.6%	1.4% Male 0.6% Female
Periodontal Disease	17.5% Male 15.9% Female	-
Calculus	65% Male 70.5% Female	-
Ante Mortem Tooth Loss	21.3%	3% Male 9% Female
Enamel Hypoplasia	10.9%	1% Male 5.5% Female
Supernumerary Teeth	1%	-
Attrition	53.6%	-
Extra Cusp	0.52%	-
Cusp of Carabelli	0.52%	-
Talon Cusp	0.52%	-
Impacted Teeth	1.04%	-
Dental Crowding	0.52%	-

The prevalence rates discussed in this chapter by previous authors are different from the rates produced in this study. In the cases of dental caries, dental abscesses, and periodontal disease, the rates quoted by others are higher than those in the current study, but the figures given may not have been adjusted for sex. However, in the case of dental calculus, ante-mortem tooth loss (the rate quoted by Roberts and Cox), and enamel hypoplasia, the figures from this study were higher than those given by others. Unfortunately, no prevalence figures were found to compare to the rates given for other dental conditions (supernumerary teeth; attrition; extra cusps; cusp of Carabelli; Talon cusp; impacted teeth; and dental crowding).

All of the dental conditions were exhibited in greater numbers by males than females in this study (when the CPR was calculated), except for the cases of an extra cusp and a Talon cusp, which are present on unsexed children, the two cases of impacted teeth, which are both present in female mandibles, and the two cases of supernumerary teeth, which belonged to one male individual and one possible female. However, when the TPR is calculated by sex, females had a much higher degree of ante-mortem tooth loss and enamel hypoplasia than males, and a slightly higher rate of caries. However, males exhibited a higher prevalence of dental abscesses than females.

The low rate of caries and high rate of calculus at sites suggests a high protein diet, with little intake of carbohydrate and sugars. Hazleton North long barrow had the highest prevalence rate for ante-mortem tooth loss, which may possibly be linked to scurvy, and significantly, 12% of the assemblage had evidence of scurvy in the bones. Ante-mortem tooth loss affected the elderly in most cases, and the very young were affected skeletally, perhaps suggesting differential access to resources for some groups, excluding others.

Chapter 10: Trauma

10.1: Introduction

Damage in the form of trauma to human skeletal remains may be accidental, activity related, pathological, caused by interpersonal violence or intervention (Roberts 2002: 338; Bennike 2008: 312-317; Galloway *et al.* 2014b: 51; Lovell 1997: 140). By studying the nature of the traumatic injury, valuable insights into the cultural practices and lives of past populations may be inferred. Traumatic insults to the skeleton may be visible in the form of fractures, dislocations, injuries inflicted with weapons, damage to the soft tissues which have ossified and formed an exostosis, by amputation, or by deliberate intervention, such as trepanation (Lovell 2008: 342; Bennike 2008: 310).

10.2: Fracture

A fracture is defined as "a disruption in the continuity of a bone" and is influenced by the direction, degree, loading rate and duration of the load sustained, together with the age and relative health of the individual affected (Hall 2003: 102). In order for bone to fracture, external forces are applied which exceed the normal plasticity of bone (Byers 2010: 274). These external forces (Table 10.1) may be produced by blunt force trauma in the form of hard objects such as clubs, the ground, or furniture, or sharp force trauma, which is inflicted with penetrating objects such as spears or knives, and also includes slashing and chopping (Lovell 2008: 341).

Table 10.1: Forces that inflict fractures on bone (After Zephro and Galloway 2014: 35-36).

Force	Action	Result	Location
Tension	**Equal and opposing loads**	**Bone pulls apart – may be accompanied by dislocation of joint**	**Tendinous insertion sites**
Compression	**Equal and opposing loads**	**Bone pushes together**	**Vertebral fractures**
Shearing	**Two opposite forces applied parallel to the surface**	**Horizontal fracture**	**Diaphysis**
Flexion (Bending)	**Opposing forces perpendicular to the surface, with angulation in the middle**	**Transverse or oblique fracture ("greenstick" in children)**	**Diaphysis**
Torsion (Rotation)	**Load twisted around axis**	**Spiral fracture**	**Diaphysis**

Fractures may be described as incomplete or complete, depending upon the extent of the injury. Incomplete fractures are characterised by a proportion of continuity between the areas of affected bone, and are more common in children than adults, due to the more robust organic nature of immature bones (Resnick and Goergen 2002: 2636). Greenstick fractures, torus fractures, bow fractures and toddler's fractures occur most commonly in children but vertical and depressed fractures mainly occur in older individuals (Galloway *et al*. 2014a: 60). Complete fractures occur when there is discontinuity between two or more fragments of bone, and can be either closed (simple) fractures, or open (compound) fractures, where not only is the bone fractured, but the overlying skin has been penetrated, allowing bacteria to enter the wound. Compound fractures are further divided into types depending on the direction and shape of the break: transverse; oblique; spiral; comminuted; and epiphyseal (Resnick and Goergen 2002: 2636).

When analysing assemblages of human skeletal remains, it is essential to be able to differentiate between ante-mortem, peri-mortem and post-mortem fractures. Ante-mortem trauma is defined as trauma inflicted before death, and in the case of skeletal human remains, must show signs of healing (either fully or partial) (Bennike 2008: 310). The healing process of a fracture is divided into three stages: the inflammatory phase, which lasts up to 72 hours; the reparative phase, which continues for about two weeks, beginning on the second day after the injury was sustained; and lastly, the remodelling phase, which may take from between six months up to seven years, and begins during the reparative phase (Waldron 2009: 146-7).

The inflammatory phase is characterised by immediate blood flow to the injured area, resulting in the formation of a haematoma which coagulates within six to eight hours, followed by cellular proliferation, in the form of fibroblasts, chrondrocytes and osteoblasts, together with vasculoneogenesis, which initiates repair beneath the external periosteum (Bennike 2008: 310). The reparative stage is characterised by fibrous union, where cartilage is replaced by skeletal tissue by the release of mineral from the bone fragments (Resnick and Goergen 2002: 2640). Finally, the remodelling phase involves the replacement of the newly formed woven bone into mature bone that approximates the original shape, but leaves visible signs of the healed fracture in adult individuals, conspicuously less so in younger individuals (Galloway *et al*. 2014b: 48).

Distinguishing between peri-mortem (at, or close to time of death) fractures and post-mortem fractures (i.e. those caused when the bone was no longer plastic, such as during excavation or curation, or fractures caused by collapse in the burial environment) may be quite difficult, as in both cases, there will be no sign of healing at the fracture site (Mays 2010: 244). Therefore, determining the timing of the fracture is very important because a peri-mortem fracture may well represent a fatal injury, especially if inflicted upon the cranium, causing brain damage (Lovell 2008: 350). Distinguishing peri-mortem fractures from those received long after death are dependent upon several factors. As living bone is very plastic due to a high water and collagen content, it can bend and deform considerably before breaking, whereas dry, brittle bone has lost this flexibility and will snap (Galloway *et al*. 2014b: 51). Peri-mortem fractures exhibit sharp, smooth edges, of an oblique or jagged nature, but post-mortem fractures are right angled, with blunt edges that are a lighter colour than the rest of the bone (Byers 2010: 287). In addition, fractures received peri-mortem can exhibit greenstick, radiating or stellate, concentric, or hinge patterning, a phenomenom not seen in dry bone (Lovell 1997: 145).

10. 2.1: Axial Skeleton

Cranial Vault Fractures

Fractures that are inflicted upon the cranium tend to be caused by direct trauma, either of accidental origin, such as a fall, or by interpersonal violence, either with a sharp or blunt object (Lovell 1997: 149). Cranial vault fractures are described by the patterning that is exhibited on the vault: linear fractures may be singular or multiple, are rarely straight, will be terminated by a sutural line or existing fracture, and are caused by direct trauma at low velocity with a large impact surface, such as floors; diastatic fractures are similar to linear fractures but differ in that the break involves the sutures of the cranium, most commonly the coronal and lambdoid sutures; depressed fractures are caused by direct impact with a blunt object, which may crush the diploïc layer and penetrate the ectocranial surface. In addition, linear fractures may radiate out from depressed fracture, clearly marking the area of impact, which may have evidence of bevelling on the ectocranial surface; stellate fractures are most commonly located on the parietals and consist of multiple radiating fractures that originate at the point of impact; and comminuted fractures, which are caused by crushing, fragmenting the vault into many pieces (Galloway and Wedel 2014a: 137-141; Lovell 1997: 149-150).

It is very difficult to assess whether a cranial fracture was inflicted intentionally or accidentally, in either healed injuries or those sustained peri-mortem. However, several textbooks used in forensic anthropology advocate using the HBL (hat brim line rule) to discriminate between head injuries received during a fall or from a blow (Galloway and Wedel, 2014b; Knight, 1991; and Spitz, 2006). In their study of 2008, Kremer and colleagues standardised the areas of the cranium delineated by the HBL (Figure 10.1) as an area that is parallel to the Frankfort Horizontal plane. In the scheme, the G Line is the area located at glabella, and the EAM (external auditory meatus) Line is the line passing through porion, and the HBL is located between the two points (Kremer *et al*., 2008: 717).

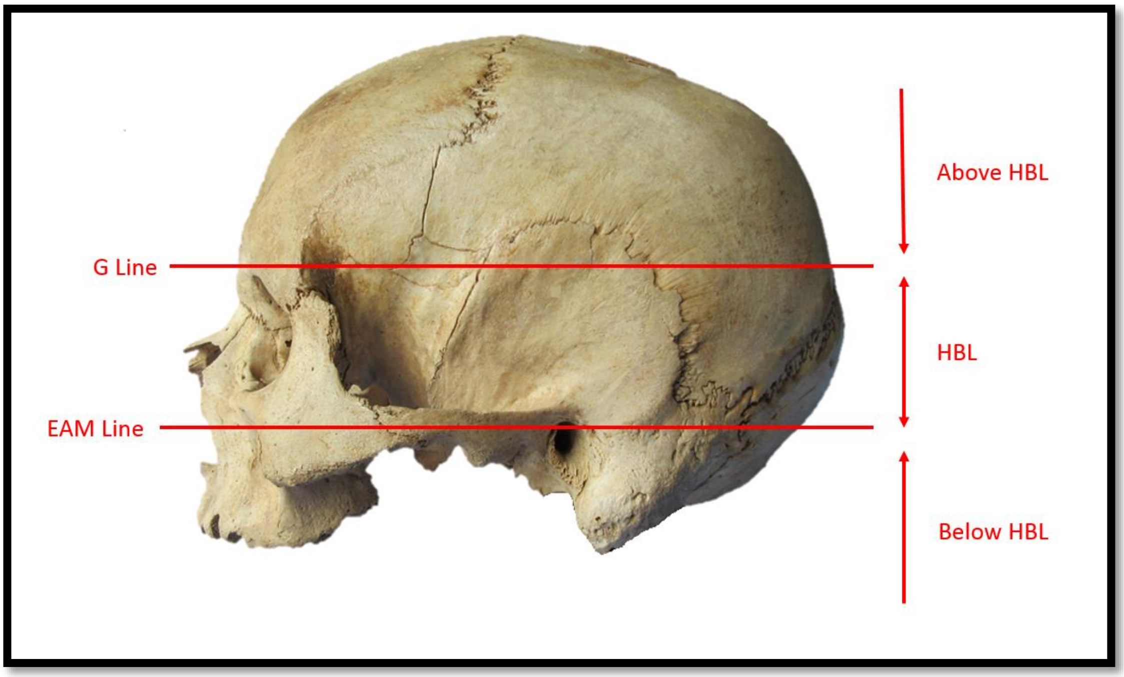


Figure 10.1: Cranium with areas at HBL, and above and below HBL (after Kremer *et al*. 2008: 717).

Over a five year period, Kremer *et al*. (2008) studied cases presented for autopsy at the Laboratoire de sciences judiciaires et de médecine légale in Montreal, where skull fractures were present. The examination of the 72 relevant cases indicated that fractures sustained above the HBL were indicative of blows inflicted with a blunt weapon in 72% (18/25) of the cases (Kremer *et al*. 2008: 717). Furthermore, their research indicated that laterality of the fracture was highly significant, in that 68% (15/19) of the cases, blows dealt by blunt weapons were inflicted on the left-hand side of the cranium, strongly suggesting an assault by a right-handed assailant (Kremer *et al*. 2008: 717). Further work by Guymarc'h and colleagues (2010) asserts that the HBL rule and laterality alone are not sufficient to gauge whether a fall or a blow caused the skull fractures witnessed at autopsy. They advocate that in addition to the above criteria, the number and length of scalp lacerations should be taken into consideration (noting the number of these injuries was also addressed by Kremer and colleagues); facial and ear contusions should be noted; that post cranial trauma should also be evaluated; and that the nature of the fracture is indicative of the cause - a depressed or comminuted fracture is the result of blows rather than falls in 100% and 80% of cases respectively (Guymarc'h *et al*. 2010: 427). However, when analysing archaeological samples, examination of soft tissue damage is not usually an option.

The study of Neolithic human skeletal remains from 42 sites for the current study revealed that eight individuals had suffered cranial vault fractures – five were considered to have been inflicted peri-mortem, and the remaining three were healed injuries, giving a CPR of 2.6% (8/305). Four of the peri-mortem cases have already been noted by researchers interested in evidence of Neolithic violence (Table 10.2), and are briefly outlined and illustrated in Figures 10.2 – 10.5. The TPR for the zones (according to the method by Knüsel and Outram, 2004) with the cranial injuries will be summarised in Table 10.3 at the end of this section.

Table 10.2: Individuals with cranial vault injuries.

Site	Timing of Injury	Reference
Belas Knap DII (EU.1.5.03)	Peri-mortem	Schulting & Wysocki (2005); Smith (2014); Smith & Brickley (2009)
Belas Knap D4 (EU.1.5.09)	Peri-mortem	Schulting & Wysocki (2005); Schulting (2012); Smith (2014); Smith & Brickley (2009)
Belas Knap CIV	Peri-mortem	-
Rodmarton (EU.1.5.069)	Peri-mortem	Smith (2014); Smith & Brickley (2009)
Littleton Drew (EU.1.5.53)	Peri-mortem	Smith & Brickley (2009); Smith *et al*. (2011)
Winterbourne Monkton (EU.1.5.044)	Ante-mortem	-
Randwick (A3081B)	Ante-mortem	-
Wor Barrow (# 8)	Ante-mortem	-

An adult female aged between 28 and 44 years from Belas Knap long barrow (# DII or EU.1.5.03) received a penetrating blow to the left parietal (probably from a right-handed assailant) with a sharp instrument, perhaps a stone axe (Figure 10.2). An ovoid shape fragment of bone measuring approximately 25mm supero-inferiorly and 13mm medio-laterally was depressed inwardly, but is still hinged at the anterior of the wound. The edges of the lesion are sharp, with no sign of healing apparent, indicating that this injury was sustained peri-mortem.

Figure 10.2: A - Adult female from Belas Knap long barrow (#DII / EU.1.5.03) with sharp force trauma to the left parietal. B – Detail.

Another individual from Belas Knap long barrow (D4 / EU.1.5.09), probably an older child or adolescent (based on the fragility and size of the cranium - no teeth were available for ageing), suffered an enormous blow to the right frontal bone, probably from a left-handed assailant. A large circular hole, measuring at least 50mm supero-inferiorly and 40mm medio-laterally (Figure 10.3), surrounded by concentric radiating lines, is evident above the right orbit but it is difficult to assess the extent of the injury, as the frontal bone is incomplete. However, the edges of the injury are sharp, with no sign of healing, indicating that the wound was sustained peri-mortem.

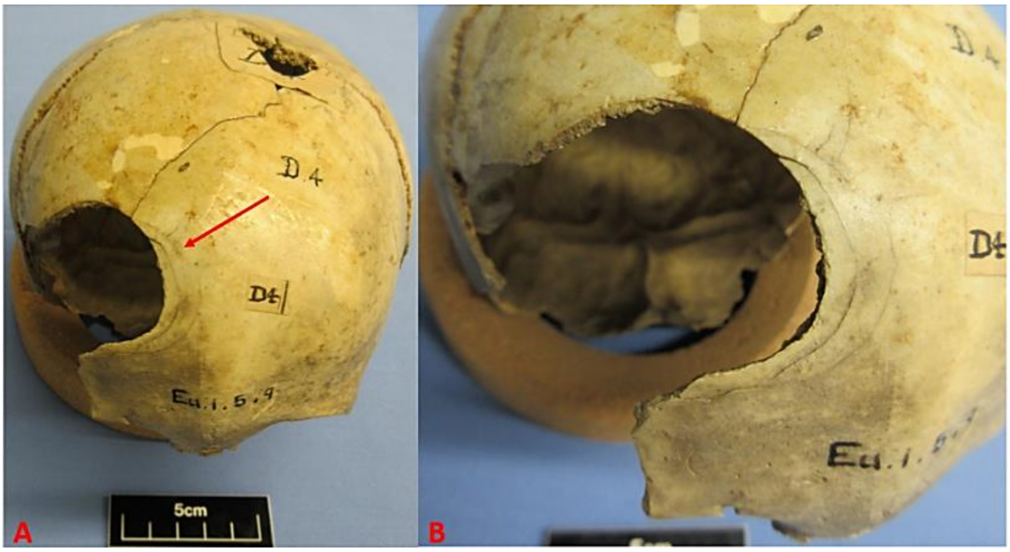


Figure 10.3: A – Child/adolescent from Belas Knap long barrow (# D4/EU1.5.09) with blunt force trauma to the right frontal bone, and concentric radiating lines (arrowed). B – Detail.

A probable adult female from Rodmarton long barrow (EU.1.5.069) of unknown age, suffered a linear (radiating) fracture, measuring approximately 7cm supero-inferiorly to the left frontal bone that has terminated at the coronal suture (Figure 10.4). The fracture has cleaved cleanly through the cranium, indicating that the blow to the cranium was delivered with some force and may have been inflicted with a blunt instrument. There are no signs of healing to the sharp edges, indicating that the injury was sustained peri-mortem.

Figure 10.4: A - Probable adult female from Rodmarton long barrow (EU.1.5.069) with linear fracture to the left frontal. B – Detail.

An adult male from Littleton drew (Lugbury EU 1.5.053) suffered a penetrating injury to the left parietal, adjacent to the sagittal suture and measuring 25mm supero-inferiorly by 10mm medio-laterally. The injury has completely penetrated both the ectocranial and endocranial surfaces, and produced bevelling to the latter (Figure 10.5). The injury may have been caused by a right-handed assailant, based on the location (side and above the HBL). The lack of healing and sharp edges would suggest that the injury was inflicted peri-mortem. However, Smith *et al*. (2011) conducted experiments on animal bones, using flint arrow heads to discern the type of wounds inflicted. The results showed a remarkable similarity to the one from Littleton Drew below, and would seem to add credence to the theory put forward by Smith and Brickley (2009: 106), that this individual could have been shot from above by an arrow.

Figure 10.5: A - Adult male from Littleton Drew long barrow (EU. 1.5.53), with penetrating sharp force trauma to the left parietal. B- Detail. C - Detail of endocranial bevelling.

Whilst reviewing instances of interpersonal violence in the Neolithic period, Schulting and Wysocki (2005) examined 350 crania, and graded the specimens as high, medium or low probability of having suffered such a fate (Schulting and Wysocki 2005: 110). One individual from Belas Knap (# C IV) was considered to be unconvincing and was therefore placed in the low category. On re-examination, the adult male cranium presents a depressed fracture, measuring 20mm supero-inferiorly by 15mm medio-laterally, on the left parietal (Figure 10.6). The fracture is ovoid in shape, possibly indicating the shape of the weapon used, and has a central smaller delineated ovoid piece of bone, which is slightly more depressed than the surrounding bone. However, the depressed fracture does not encroach onto the endocranial surface. There are three radiating fractures with irregular margins on the left parietal leading from this injury, one superiorly, measuring approximately 10mm in length (# 1 on Figure 10.6B), and two inferiorly towards the temporal bone, measuring 50mm in length (# 2), and 45mm in length (#3).

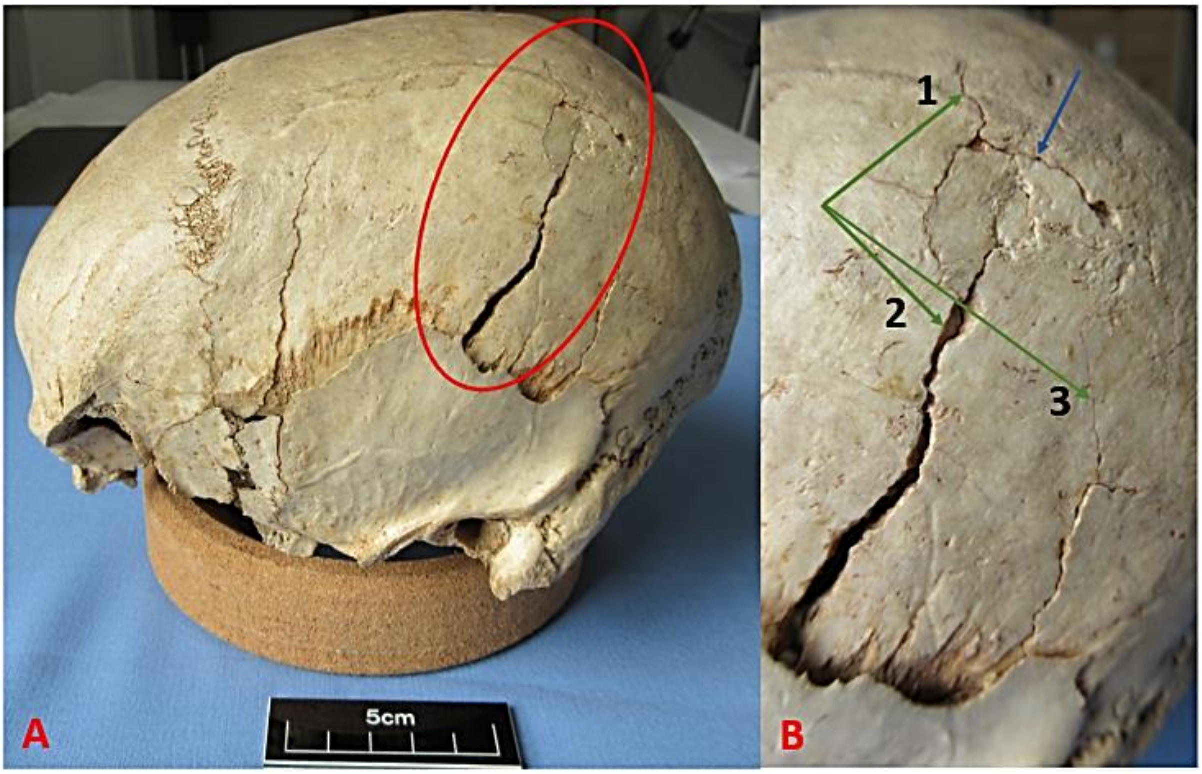


Figure 10.6: A – Adult male (# C IV) from Belas Knap long barrow, exhibiting depressed fracture on the left parietal. B- Detail – radiating fractures (green) and depressed fracture (blue arrow).

The cranium illustrated above exhibits a fracture that is depressed, shows no sign of healing, is located on the left side of the cranium, and above the HBL. Unfortunately, there are no extant facial bones or indeed, any post cranial bones to examine. Three of the criteria are pertinent to this individual, suggesting a peri-mortem blow, caused by a blow to the head, by a right-handed assailant. However, the fact that the margins of the radiating fractures are irregular, may indicate that the trauma was sustained post mortem.

Three individuals appear to have suffered well-healed ante-mortem injuries to the cranium, which have not been reported before. In all three cases, the injury was to the right frontal, superior to the orbit. Two of the individuals are male, the other female. The adult female, from Winterbourne Monkton (EU 1.5.044) exhibits two injuries: a healed depressed fracture, measuring 40mm by 22mm, with a clearly defined oval outline and an area of porosity in the centre; and a healed linear fracture above the right orbit, which measures 20mm medio-laterally (Figure 10.7). Neither injury involves the endocranial surface. Unfortunately, there are no other extant bones to examine for other healed injuries. However, Schulting and Wysocki (2005) consider this type of healed depressed fracture to represent interpersonal violence, delivered by a mild blow to the head (Schulting and Wysocki 2005: 118).

Figure 10.7: A - Adult female from Winterbourne Monkton (EU 1.5.044), with healed depressed fracture to right frontal (red circle) and healed linear fracture above right orbit (yellow arrow). B – Detail of healed depressed fracture. C – Detail of healed linear fracture above right orbit.

A male adult from Randwick long barrow (#A3081b) has a well-healed depressed fracture on the right frontal bone, measuring 12mm medio-laterally by 5mm supero-inferiorly, which is visible as a concave, ovoid structure with a roughened centre (Figure 10.8). Unfortunately, this individual is only further represented by a mandible, which shows no evidence of trauma.

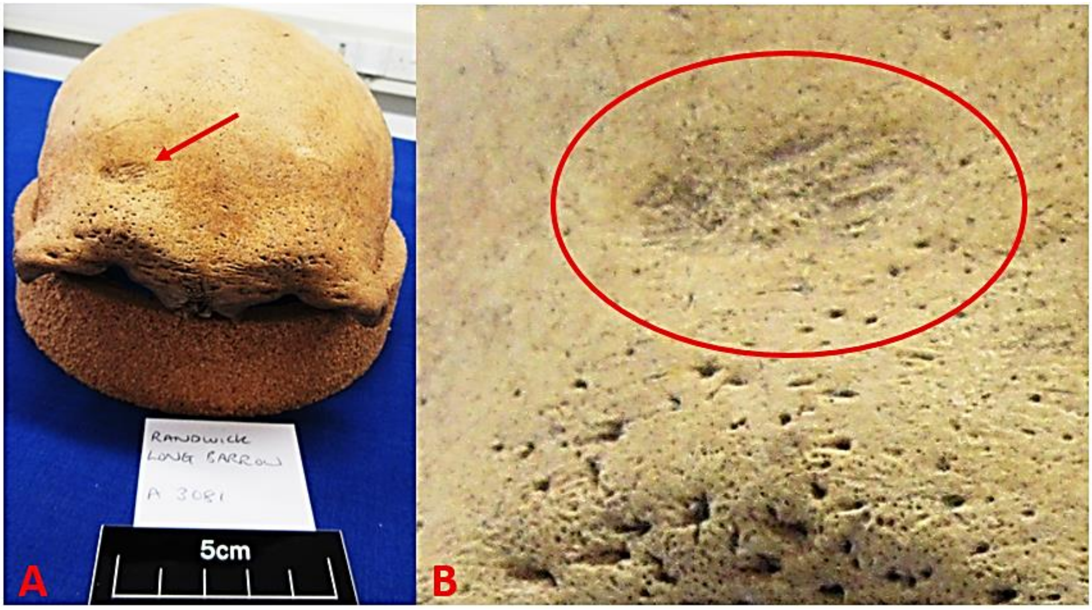


Figure 10.8: A – Adult male from Randwick long barrow (#A3081B) with healed depressed fracture to right frontal (red arrow). B – Detail.

Another male adult from Wor Barrow (Skeleton # 8), also exhibits an ovoid healed depressed fracture, superior to the right orbit. The fracture measures 20mm medio-laterally by 7mm supero-inferiorly, and has a clear raised outline (Figure 10.9). The remaining bones from the partial skeleton, which is only 16.4% complete, based on the Zonation Method by Knüsel and Outram (2004), show no further sign of trauma.

Figure 10.9: A - Adult male from Wor Barrow (# 8), with healed depressed fracture to right frontal (red arrow). B - Detail.

Table 10.3: TPR for the individuals with cranial injuries by zone and sex.

Site	Sex	Bone Affected	Zone	TPR %
Belas Knap DII (EU.1.5.03)	F	Left parietal	4	2.4% (1/41)
Littleton Drew (EU.1.5.53)	M	Left Parietal	4	4.1% (2/49)
Belas Knap CIV	M	Left Parietal	4	
Rodmarton (EU.1.5.069)	F	Left Frontal	2	2.3% (1/43)
Belas Knap (EU.1.5.09)	JUV	Right Frontal	1	-
Winterbourne Monkton (EU.1.5.044)	F	Right Frontal	1	2.6% (1/38)
Randwick (A3081B)	M	Right Frontal	1	3.6% (2/55)
Wor Barrow (# 8)	M	Right Frontal	1	

Nasal Fractures

The fragile nasal bones are particularly susceptible to injury, due to their projection from the cranium and associated vulnerability (Galloway and Wedel 2014a: 150). In modern populations, this type of fracture is the most common injury inflicted upon the face, often as the result of punching or kicking, but may also be sustained during a fall (Walker 2011: 582; Galloway and Wedel 2014a: 150). Fractures of the nasal bones may be produced by forces impacted from the front, causing the nasal bones to fracture at the junction of the naso-maxillary suture and ethmoid, or laterally, where the tips of the nasal bones and the adjacent orbital rim are frequently involved (Galloway and Wedel 2014a: 150-151).

Only one individual from the current study exhibited a fracture to the nasal bones, which has previously been noted by Smith (2014), giving a CPR of 0.3% (1/305) and a TPR of 5.2% (1/19). An elderly female from Lanhill long barrow (# EU 1.5.105) has a fracture to the left nasal bone, which has healed, but projects anteriorly to the adjacent frontal process of the maxilla, and when viewed from the anterior, the nasal bones are skewed in a 45^{o} angle to the right (Figure 10.10). In addition, there is also a healed fracture to the adjacent inferior orbital rim. The location of the nasal fracture implies that the injury was inflicted by a lateral blow to the nose, possibly fracturing the inferior left orbital rim at the same time, and possibly by a right-handed aggressor.

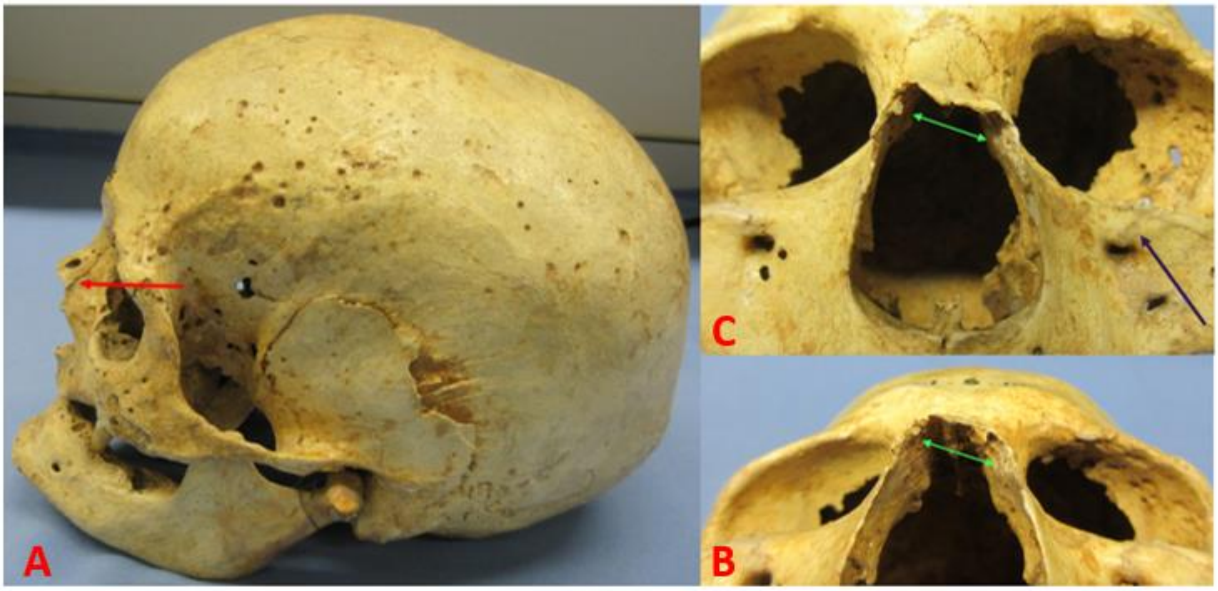


Figure 10.10: A - Elderly female from Lanhill long barrow (EU 1.5.105), with lateral fracture to the left nasal bone (red arrow). B - 45° angle of healed fracture (green arrow). C - Healed fracture to inferior orbital rim (purple arrow).

Zygomatic Fractures

Fracture of the zygomatic bone is the second most common form of facial fracture, again due to its prominence on the face, and is most commonly caused by assault, together with sports injuries and motor vehicle accidents in modern populations (Tadj and Kimble 2003: 49). Fractures of this type have been divided into three categories by Zingg and colleagues (1992: 779): Type A fractures are caused by low impact force to one of the zygomatic pillars – A1 is an isolated zygomatic arch fracture, A2 is a lateral wall fracture, A3 is an infraorbital rim fracture; Type B fractures are called tetrapod fractures, as all of the above pillars are broken, plus the frontal process where it articulates with the sphenoid; and Type C fractures that involve all four articulations (as above), but with fragmentation (Zingg *et al.* 1992: 779).

Three individuals from the current study exhibited fractures to the zygomatic bone, one of which (the elderly female from Lanhill long barrow) has been previously noted by Smith and Brickley (2009) and Smith (2014), giving a CPR of 1% (3/305). One of the individuals, an adult male from Belas Knap long barrow (EU.1.5.04) suffered a Type A1 fracture to the left zygomatic arch, where it communicates with the temporal process at the zygomaticotemporal suture (Figure 10.11), giving a TPR of 5.5% (1/18). The fracture has healed but there is a non-union between the two processes.

Figure 10.11 Adult male from Belas Knap long barrow (EU.1.5.04), with a healed fracture and non-union of the left zygomatic arch.

An elderly female from Lanhill long barrow (featured in Figure 10.10) suffered a triple Type A1 fracture to the right zygomatic arch (Figure 10.12), giving a TPR of 6.7% (1/15). The injury has healed but clearly shows the point of impact in the centre of the bone (arrow B), a fracture anterior to the impact (arrow A), and a fracture posterior to the blow (arrow C), (after Byers 2010: 324).

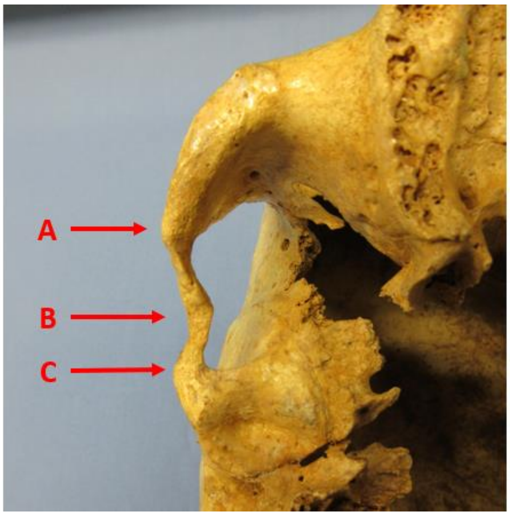


Figure 10.12: Inferior view of the cranium of elderly adult female from Lanhill long barrow with triple fracture of the zygomatic process (A= fracture posterior to point of impact B= fracture at point of impact C= fracture posterior to impact).

A possible adult female from Hazleton North long barrow (# 8754) exhibits a Type B fracture of the right zygomatic bone, which has been broken at the frontal process and at the temporal process (Figure 10.13A). Furthermore, the maxillary process has been fractured at the zygomaticomaxillary suture and a zygomatico-orbital fracture has been sustained to the inferior rim of the right orbit (Figure 10.13B). All of the fractures were healing when death occurred and show signs of porosity and new bone formation.

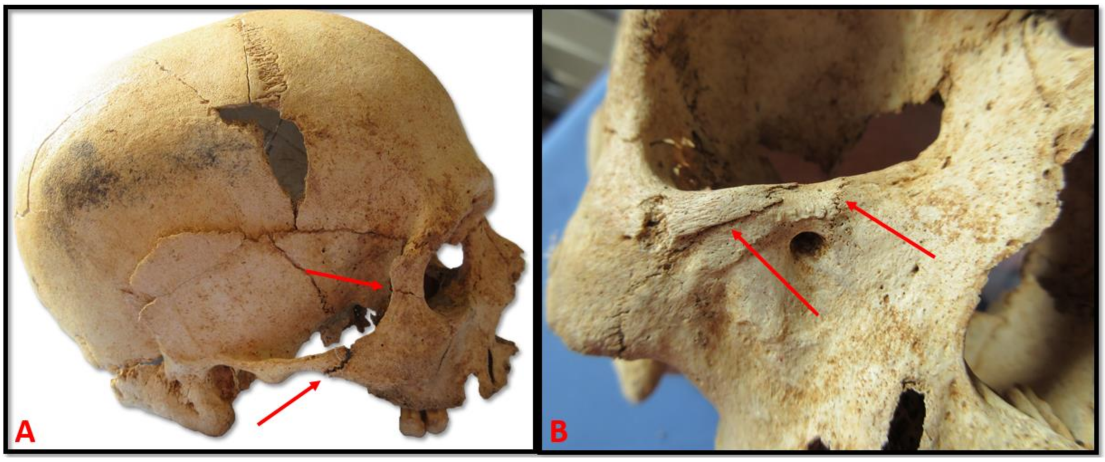


Figure 10.13: A - Possible female from Hazleton North long barrow (# 8754), with fractures to the right frontal process and temporal process. B - Fractures to the right maxillary process and a zygomatico-orbital fracture to the inferior orbital rim.

Fractures of the Clavicle

The clavicle may be fractured by falls, either simple or from a height, by violence, or in modern populations, during sporting activities and in motor vehicle accidents (Robinson 1998: 481). In addition, the clavicle is particularly susceptible to fracture during natural childbirth, and in young children, is the most common form of fracture due to its vulnerable subcutaneous location (Moczygemba *et al*. 2010: 4; Calder *et al.* 2002: 331; Resnick 2002: 2810). In adults, fracture of the clavicle occurs more commonly in males, with a peak of incidence between 13 and 20 years of age, and again over 70 years of age, conversely affecting females less, but with a small rise in numbers over 80 years of age (Robinson 1998: 480). The clavicle commonly fractures in three different areas - the diaphysis, and the medial and lateral ends, with the diaphysis the most common site, representing 75% of fractures to the clavicle (Postacchini *et al*. 2010: 731; Robinson 1998:478).

One individual from the current study presented a fracture of the right clavicle, giving a CPR of 0.3% (1/305) and a TPR of 6.3% (1/16). An adult female from West Kennet long barrow (Skeleton IX) suffered a fracture to the mid - diaphysis, with a well-healed callus, indicating that the injury was sustained ante-mortem (Figure 10.14). The fracture has not healed cleanly and there is an overlap in the bone which has twisted the diaphysis slightly. The bone measures 106mm and is shorter than the opposing clavicle which measures 115.7mm in length. Additionally, due to the bulky overlap on the mid-diaphysis, the right clavicle has a circumference of 47mm, opposed to 39mm on the left.

Figure 10.14: Right clavicle from an adult female from West Kennet long barrow (Skeleton IX), with a well-healed callus (red arrow).

Rib Fractures

Rib morphology allows for a great deal of inward pressure to be borne before a fracture occurs, and some ribs are more vulnerable to injury than others – the most commonly broken ribs are the sixth to the eighth (Galloway and Wedel 2014c: 189). Rib fractures may be caused by falls, accidents or direct blows to the chest, and are classified as transverse or oblique fractures - the former are caused by direct blows to the chest wall, the latter by falls from a height, or in modern populations, in motor vehicle accidents (Galloway and Wedel 2014c: 190).

Only two rib fragments from two individuals from Hazleton North long barrow presented evidence of fracture in the current study, giving a CPR of 0.6% (2/305). No TPR is available for this element as there were thousands of rib fragments within the assemblages which were unable to be reconstructed and would not therefore give an accurate number of whole elements. The reasons for the low number of rib fractures in this study are two-fold: many of the human remains from Neolithic sites examined for this project consisted of crania and mandibles only; and where there were extant collections of ribs, most were badly fragmented, and evidence of fractures where difficult to identify. Even if there were examples of fractured ribs on excavation, over time, many will have been broken at the fracture site due to the fragile nature of the bones, and the evidence lost. However, one adult fragment of rib (# 6093) presented a healed fracture to the mid-shaft, in the form of a depressed oblique line. A partially complete left rib from a child (# 4100) had evidence of a healing fracture at the point of the lateral curvature (Figure 10.15, point C). The rib was thickened throughout the mid-shaft (point B), and flatter towards the lateral end (point A).

Figure 10.15: Left - Partial left rib from a child from Hazleton North long barrow. A – Flattened portion of rib B- area of thickened bone C- healing fracture, with porosity. Right – detail.

Vertebral Fractures

Most vertebral fractures are caused by indirect trauma to the spinal column, through extreme extension, flexion, rotation, compression, shearing action, or a combination of these actions (Galloway and Wedel 2014c: 163). However, direct trauma can cause fractures to the transverse processes, when delivered by either interpersonal violence or falls (Lovell 2008: 354). In addition, stress fractures, which may or may not completely separate the neural arch from the body of the vertebrae, a condition called spondylolysis, are caused by an initial acute overload, followed by repetitive trauma, which discourages union of the fragmented parts (Merbs 1996; 207-211). Another stress fracture, the “clay-shoveller’s fracture” involves separation of the tip of the spinous process of the seventh cervical vertebra or the first thoracic vertebra, and is caused by manual handling of heavy soils (Knüsel *et al*. 1996: 429). However, the most common finding of vertebral trauma found in archaeological populations is compression and fracture of the vertebral bodies, caused by sudden vertical compression, leading to the rupture of the intervertebral disk, which forces disc tissue into the body (Lovell 2008: 355).

The current study produced two examples of vertebral fracture, and in both cases, these were not designated to a particular skeleton and were incomplete, giving a CPR of 0.6% (2/305). However, the fracture lines are quite clear. An un-numbered lumbar vertebra from West Kennet long barrow has suffered a fracture to the right superior aspect of the vertebral body, which extends towards the mid posterior of the bone (Figure 10.16A). A thoracic vertebra from Hazleton North long barrow (# 11381) also has a fracture to the right superior aspect of the vertebral body (Figure 10.16B). Both of these injuries are consistent with the application of vertical compression, leading to a rupture of the intervertebral disc.

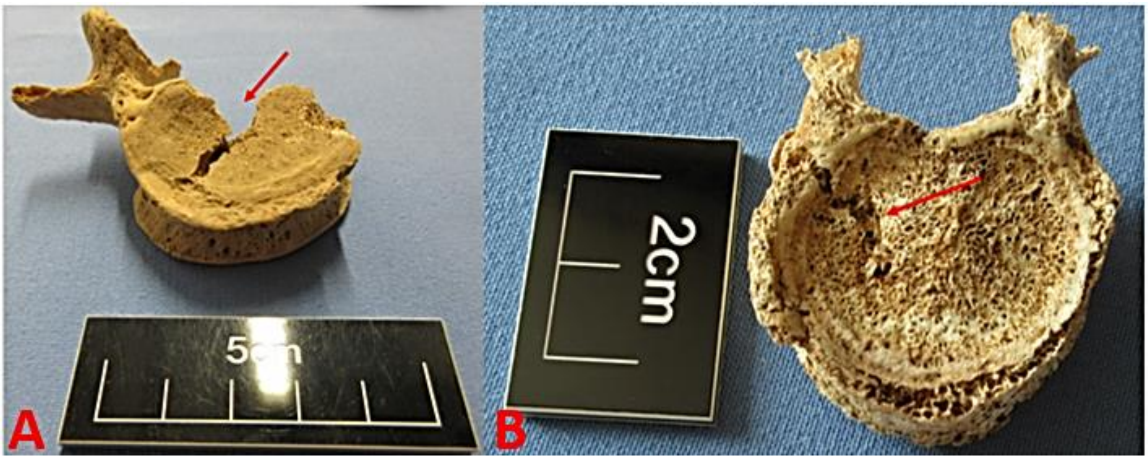


Figure 10.16: A– lumbar vertebra from West Kennet long barrow, with compression fracture to the right side of the body (red arrow). B – Thoracic vertebra from Hazleton North long barrow, with compression fracture to the right side of the body (red arrow).

10.2.2: Upper Limb Fractures

Humerus

Fractures to the humerus are divided into proximal, distal and shaft fractures. In adults, the most common humeral fracture is located at the proximal end, either by fracture of the neck, which is caused by indirect trauma such as a fall onto an outstretched hand, or by direct trauma from a blow or a fall onto the shoulder, which may cause a fracture to the greater tuberosity, or force the humeral head into the glenoid fossa of the scapula (Lovell 2008: 359-60). In addition, there is a rising incidence of proximal humeral fracture in mature females in modern populations, due to the bone loss associated with the post-menopausal years (Galloway 2014b: 203). Children are also vulnerable to fracture of the proximal humerus, due to the possibility of the separation of the epiphysis, which occurs before the age of five years (Galloway 2014b: 203).

Fractures to the humeral shaft most commonly occur mid-shaft and are usually of the spiral or transverse type (Lovell 1997: 160). Mid-shaft fractures are predominately caused by accidents or interpersonal violence – older individuals are susceptible to simple falls or rotational injuries, and younger individuals most commonly sustain this type of injury from assaults, falls from a height, from throwing objects, and in modern populations, in motor vehicle accidents (McKee and Larsson 2010: 1001).

Fractures of the distal humerus occur in the condylar, supracondylar, and epicondylar regions, and are more common in children (Galloway 2014b: 209; Resnick 2002g: 2824). Supracondylar fractures are caused by a fall onto an outstretched hand, the most common cause of which is falls from climbing, and account for between 30% and 50% of elbow fractures in children (Lovell 2008: 360; Galloway 2014b: 209). In adolescent and older individuals, there is a bimodal age distribution of fracture patterns for the distal humerus – a peak between 12 and 19 years (usually in males), and in those aged over 80 years (usually females) (Athwal 2010: 946). Fractures to the epicondylar and condylar regions tend to be caused by falls, and can produce avulsion fractures (Galloway 2014b: 210).

There was only one example of peri-mortem fracture to the humerus in the current study, giving a CPR of 0.3% (1/305) and a TPR of 2% (1/51). An isolated left humerus from Rodmarton long barrow (# unmarked XXIV) had suffered a spiral fracture to the mid-shaft (Figure 10.17A). The edges of the fracture are sharp and irregular and there is a conchoidal impact scar on the lateral aspect of the bone (Figure 10.17B), all features consistent with a peri-mortem fracture (E. Johnson, pers. comm.).

Figure 10.17: A – Peri-mortem fracture to the left humerus from Rodmarton long barrow (unmarked XXIV). B – Detail of the edges of the fracture and a conchoidal impact scar on the lateral aspect of the bone.

Another individual, an adult male from Lanhill long barrow (# EU.1.5.109) suffered a severe injury to the left humerus (Figure 10.18A), which has previously been described by Smith and Brickley (2009). The distal humerus, in particular the elbow, has been injured, possibly during growth, which has caused malformation to the joint. The trochlea is deformed and does not allow proper anatomical articulation with the ulna (Figure 10.18B & C), which has a distorted radial notch (Figure 10.19A). In addition, the capitulum is malformed, and the corresponding head of the left radius has lost its normal morphology of a cup-shape, and has a flatter and slightly convex appearance (Figure 10.19B & C). In consequence, the elbow would have not have been able to function properly. The fact that the left humerus is far less robust than the right (Table 10. 4), suggests that this individual had suffered atrophy of the muscles, which not only affected the effectiveness of the elbow joint, but that also of the upper limb and shoulder joint, through impairment caused by the injury.

Table 10.4: Difference in size of the humeri of adult male from Lanhill long barrow (EU.1.5.109).

Humerus	Left	Right
Length mm	**279**	**292**
Head Diameter	**41.3**	**45.4**
Epicondylar Breadth	**54**	**58**

Figure 10.18: A – Anterior view of left humerus from adult male from Lanhill long barrow (EU.1.5.109) with malformed elbow joint. B – Detail. C – Distal view.

Figure 10.19: A: Left ulna from adult male from Lanhill long barrow (EU1.5.109) with malformed radial notch. B – Convex head of left radius. C – Superior view of radial head.

Radial Fractures

The most common radial fracture is that of the distal portion, caused by a fall onto the outstretched hand (a Colles' fracture), which is characterised by posterior displacement of the distal end of the diaphysis (Lovell 2008: 363). This injury accounts for approximately 16% of all fractures treated clinically, and is witnessed in three main age groups; in children aged between five and 14 years of age; in males aged below 50 years of age; and in older females aged 40 and above (a high percentage are due to osteoporotic bone, associated with post-menopausal onset) (Ruch and McQueen 2010: 830). In order for the radial diaphysis to be broken, a considerable amount of force needs to be exerted directly upon the bone, either by a blow in the form of a hard object, a fall from standing height, or in modern populations, in motor vehicle accidents (Chow and Leung 2010: 882). Most fractures to the radial shaft are situated midshaft, and are usually of the oblique type, although spiral fractures do occur (Galloway 2014b: 220). Fractures of the proximal radius occur in either the head or neck, the former are more common in adults, and the latter in children (Lovell 2008: 363).

Two adults from the current study had evidence of radial fracture, giving a CPR of 0.6% (2/305). A mature probable female from West Kennet long barrow (Skeleton 1) has a healed Colles' fracture to the left radius (see Chapter 6), possibly due to osteoporosis. Another individual from West Kennet long barrow, an adult male (EU 1.5.140) has a well-healed oblique fracture to the left radius which is situated approximately midshaft (Figure 10.20) giving a TPR of 7.7% (1/13). The bone has not healed perfectly, due to displacement of the broken ends and rotational deformation, and may have caused problems with the biomechanical function of the forearm.

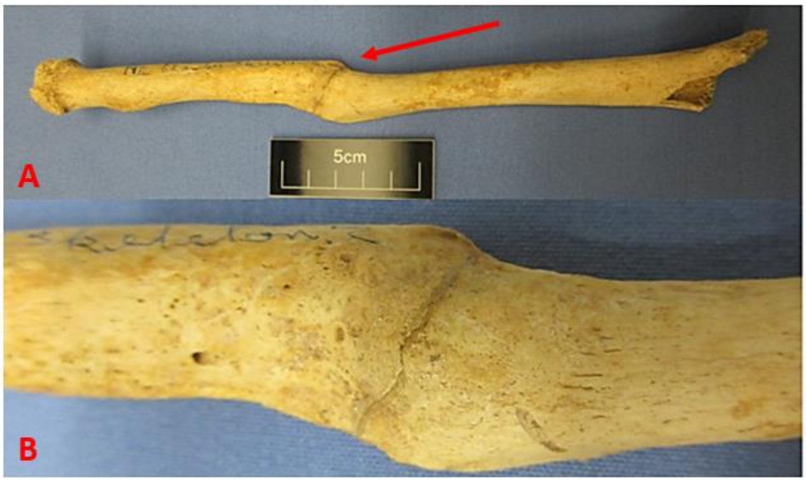


Figure 10.20: A - Healed oblique fracture to the left radius of an adult male (EU. 1.5.140) from West Kennet long barrow. B – Detail.

Ulnar Fractures

Fractures to the ulna may occur at the elbow joint, either on the olecranon or coronoid processes, or on the shaft. Fractures to the olecranon process are usually associated with falls onto the point of the elbow or direct blows, and whilst uncommon, fractures to the coronoid process are usually caused by posterior dislocations of the elbow (Galloway 2014b: 224-225). Fractures to the proximal and middle thirds of the ulna shaft with a concomitant radial head dislocation are called Monteggia fractures, and fractures to the distal third of the ulna are called "nightstick" or "Parry" fractures, resulting from direct blows to the forearm, in which the individual has attempted to block a blow to the head (Chow and Leung 2010: 882).

Two individuals from the current study have evidence of ulnar fractures, giving a CPR of 0.6% (2/305). A probable male adult from Haddenham long barrow (Skeleton A) has a possible healing parry fracture to the left ulna, with extensive callus formation evident, and a slight overlap in the horizontal plane, giving a TPR of 3% (1/34) (Figure 10.21A). An adult male from Hazleton North long barrow (Skeleton D) also has a possible parry fracture to the right ulna, with evidence of well-healed callus, giving a TPR of 10% (1/10) (Figure 10.21B). This individual is considered to have possibly been suffering from polio, and has a significantly atrophied forearm as a consequence (Chapter 7).

Figure 10.21: A – left ulna from probable adult male from Haddenham long barrow, with healing parry fracture (red arrow). B – Right ulna from adult male from Hazleton North long barrow (Skeleton D), with healed parry fracture (red arrow).

10.2.3: Lower Limb Fractures

Fibular Fractures

Fractures of the fibula can occur at the head, neck, shaft or in the distal portion and are particularly vulnerable to breakage from direct blows to the leg, due to its anatomical position (Galloway 2014a: 288; Resnick 2002: 2879). The most common form of fracture of the fibula is at the ankle joint, where the lateral malleolus can be broken by abduction and/or lateral rotation (Lovell 1997: 163). Isolated fractures to the diaphysis of the fibula are quite rare and are typically caused by falls, and in modern populations, by sporting injuries and motor vehicle accidents (Court-Brown *et al*. 2010: 71). Fractures to the head of the fibula are usually associated with lateral tibial condyle fractures, and inward forces can cause avulsion fractures anterior to the styloid process of the fibula (Marsh 2010: 1792; Manaster and Andrews 1994: 115-116).

Four individuals from the current study revealed evidence of fractures to the fibula, giving a CPR of 1.3% (4/305). Table 10.5 gives the details of the injuries and the TPR for the area of the fibula affected.

Table 10.5: Individuals in this study with fractures to the fibula.

Site	Sex	Side	Location	Length mm	TPR %
Rodmarton (un-numbered)	?	Left	Proximal	186 max	4.8% (2/42)
Wor Barrow (# 5)	F?	Left	Proximal	310	
Hazleton North (Skeleton 7665/5234)	?	Right	Proximal	366	2.1% (1/48)
Hazleton North (Skeleton 1)	M	Left	Distal	Un-measured	8.3% (1/12)

A disarticulated adult fibula from Rodmarton long barrow (un-numbered) has a fracture to the proximal diaphysis of the left fibula, with a callus on the lateral side (Figure 10.22A), possibly caused by a blow to the side of the leg. The fracture is well-healed but there is displacement evident on the diaphysis. A probable female from Wor Barrow (Skeleton # 5) also had a well-healed fracture to the lateral side of the proximal left fibula that also exhibits evidence of displacement (Figure 10.22B). The corresponding left tibia shows no sign of injury.

Figure 10.22: A – adult from Rodmarton long barrow with healed fracture to lateral side of left fibula. B – Healed fracture to lateral side of left fibula of possible adult female from Wor Barrow (Skeleton # 5).

An adult male from Hazleton North long barrow (Skeleton #1) suffered a well-healed fracture to the distal end of the left fibula on the lateral side, which exhibits evidence of displacement (Figure 10.23A, red arrow). The injury has caused rupture of the interosseous ligament which has ossified on the medial aspect of the diaphysis (Figure 10.23A yellow arrow). The left tibia of this individual is unaffected.

Figure 10.23: A - Adult male from Hazleton North long barrow (Skeleton #1) with healed fracture to distal fibula with evidence of displacement (red arrow) and an exostosis caused by ruptured interosseous ligament (yellow arrow). B – Detail.

Another individual from Hazleton North long barrow, represented only by a right fibula (# 7665/5234), has suffered a fracture to the fibular neck (with displacement) and an avulsion fracture of the styloid process of the proximal fibula. The articular surface of the head has remodelled and flattened as a consequence (Figure 10.24).

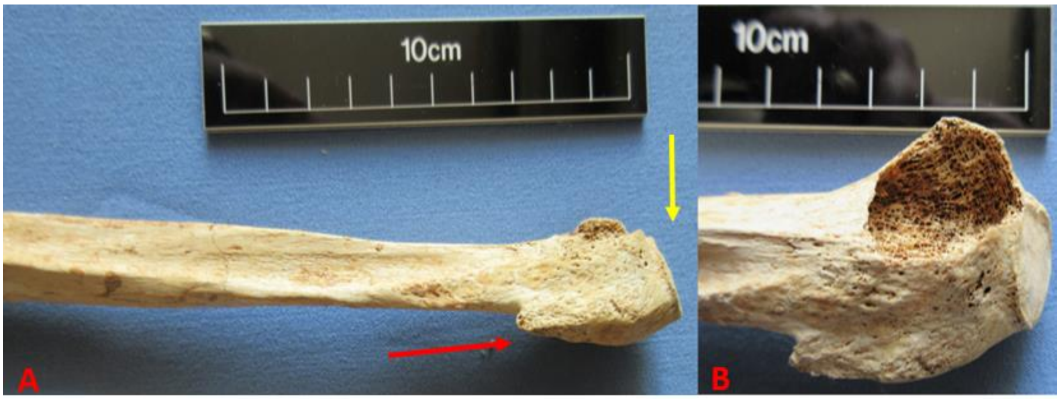


Figure 10.24: A – Isolated fibula from Hazleton North long barrow (#7665/5234) with fracture to fibular neck (red arrow) and avulsion fracture of the styloid process, and remodelled and flattened articular surface (yellow arrow). B – Detail.

10.3: Soft Tissue Injuries

10.3.1 Myositis Ossificans Traumatica

Myositis ossificans traumatica is the term to describe injuries sustained when tendinous or muscle insertions into bone are damaged, causing a haematoma which calcifies and eventually ossifies (Aufderheide and Rodríguez-Martin 2011: 26: Resnick 2002h: 4644). This soft tissue injury can occur at any tendinous or muscle attachment site where trauma has occurred, but the most common affected areas are the extensors and adductors of the thigh, the *deltoid* and *pectoralis* muscles of the arm, and at the shoulder and hip joints (Ortner 2003: 134; Resnick 2002h: 4643). Myositis ossificans traumatica can be differentiated from bony tumours and exotoses as the latter are usually much smaller and are related to the epiphyseal line, and the former are not self-limiting and tend to be irregular in shape - in contrast, lesions produced by myositis ossificans traumatica are covered in a thin outer cortex, with a well-developed trabecular interior (DiMaio and Francis 2001: 161).

The current study has produced three cases of myositis ossificans traumatica, giving a CPR of 1% (3/305). The first individual, from Hazleton North long barrow, is represented only by an isolated right fibula (# 9984), and has suffered a traumatic injury to the attachment of the *M*. *tibialis posterior*, giving a TPR of 2.1% (1/48). The ossified tissue measures 22m supero-inferiorly, and protrudes 7mm from the surface. The outer surface of the lesion is smooth, and the interior is composed of trabecular bone (Figure 10.25).

Figure 10.25: A – right fibula of adult from Hazleton North long barrow, with myositis ossificans traumatica to attachment of *M. tibialis posterior*. B – Detail.

The second individual is a possible female from Wor Barrow (#5), who has sustained an injury to the soleal line on the posterior of the right tibia, where it gives rise to *M*.

soleus (Figure 10.26), giving a TPR of 1.7% (1/59). The ossified lesion measures 25mm in supero-inferiorly and 10mm medio-laterally, protruding at least 10mm from the surface (unfortunately damaged post excavation).

Figure 10.26: A - right tibia from possible female from Wor Barrow (#5), with myositis ossificans traumatica to *M. soleus*. B – Medial view and detail.

The last case of myositis ossificans traumatica is from an individual from Hazleton North long barrow (# 4320), represented only by an isolated and fragmented fifth left metatarsal, giving a TPR of 2% (1/51). A lesion measuring 13mm supero-inferiorly and 2mm medio-laterally protrudes 6mm from the lateral surface of the bone. The lesion rises from the site of the third *M. plantar interossei* and is very irregular in shape (Figure 10.27).

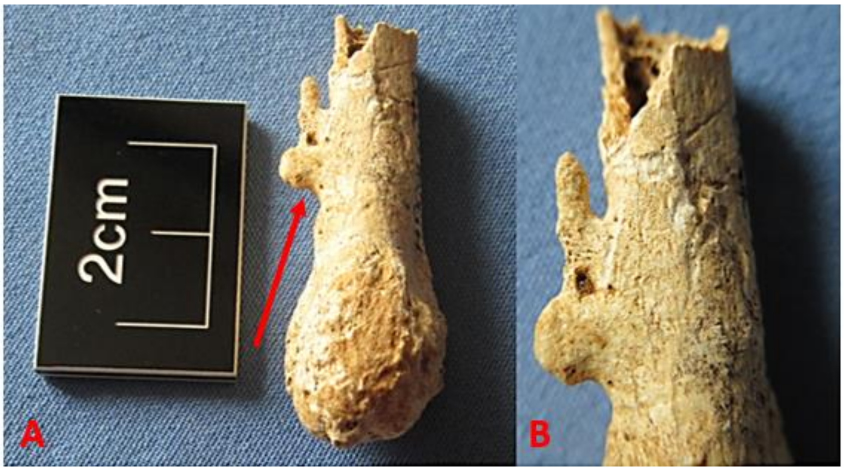


Figure 10.27: A – Lateral view of fifth left metatarsal of adult from Hazleton North long barrow (# 4320) with myositis ossificans traumatica to the attachment for the third *M. plantar interossei*. B – Detail.

10.3.2: Cortical Defects

Cortical defects are defined as porous grooves for attachment of the *M*. *pectoralis major, M*. *latissimus dorsi*, or *M*. *teres major* on the proximal humerus, and are a normal variant in children, adolescents, and young adults (especially those individuals who are physically very active), but rare in adults, as the groove gradually infills by adulthood (Mann and Hunt 2005: 125). Evidence of cortical defects in adults can be linked to several processes: as expressions of repeated stress on the muscle insertion sites; the perduration of a metaphyseal gap; bone tearing during trauma; or erosive calcifying enthesopathies of the muscle insertions (Villotte 2009: 391).

Four individuals from the current study had evidence of cortical defects to the proximal humerus, giving a CPR of 1.3% (4/305). Two are both young men in their early twenties (Wor Barrow # 3 and Lanhill EU 1.5.110) who have deep cortical defects at both the insertion site of the *M. pectoralis major* and *M. teres major*, and in the case of Wor Barrow # 3, in both arms. However, these defects are not uncommon in physically active young adults, and may well have healed with age. Two mature adults from Hazleton North long barrow and Wor barrow also exhibit this defect. Both injuries are exhibited on the left proximal humerus, giving a TPR of 4% (2/51). The adult from Wor Barrow (#5) is a possible female and has a shallow cortical defect on the left proximal humerus, at the insertion point of the *M*. *pectoralis major*, measuring 25mm supero-inferiorly and 4mm medio-laterally (Figure 10.28A). The other individual from Hazleton North long barrow is represented by a single humerus, and exhibits a deep lesion at the site where the *M*. *pectoralis major* inserts, measuring 27mm supero-inferiorly and 4mm medio-laterally (Figure 10.28B & C).

Figure 10.28: A- Adult possible female (#5) from Wor Barrow, with shallow cortical defect to left proximal humerus at the insertion site of *M. pectoralis major*. B- Left humerus from adult from Hazleton North long barrow (# 3663), with deep lesion in proximal humerus where *M. pectoralis major* inserts. C - Detail.

10.4: Trepanation

Trepanation involves surgical intervention to gain access to the cranial cavity, whilst avoiding injury to the delicate organ within, and in order to do this, it is necessary to remove a fragment of bone (Aufderheide and Rodríguez-Martin 2011: 31). The procedure can be performed by several methods: scraping, where the neurocranium is gradually abraded; grooving, which involves repeated cutting of a circular or oval shape to eventually remove the disc of bone; rectangular intersecting, where a rectangular piece of bone is removed by cutting in intersecting lines; and boring and cutting, where a circle of small holes are drilled and any remaining fragments between are cut to allow removal of the disc (Verano 2016: 2). The practice of trepanation has a wide geographical distribution, and examples have been excavated in Europe, North Africa, Australia, the Pacific, North and South America, and the Middle East (Ortner 2003; 169; Aufderheide and Rodríguez-Martin 2011: 31). In Britain, trepanation has been practised for thousands of years, with evidence of the procedure dating back to the Neolithic period up to the Post-Medieval period in archaeological assemblages (Roberts and McKinley 2005: 59-61). Trepanation may have been carried out for a variety of reasons in the past, including treating head injuries and to relieve pressure on the brain, especially in skull fractures (Bennike 2008: 320). Additionally, it has been suggested that the procedure was used as a treatment to alleviate headaches and epilepsy and as a means to remove discs of bones from captives to wear as amulets (Brothwell 1981: 121).

Three individuals from the current study were considered to show evidence of trepanation, giving a CPR of 1% (3/305). The first individual, from Bisley long barrow (Avenis, or Smart's Farm long barrow) has evidence of an incomplete trepanation on a fragment of frontal (Wilson Parry 1923: 456.2), a replica of which is held at Stroud Museum (the original is held at the British Museum). The fragment exhibits an attempted trepanation of the "grooving" type (unmeasured), which was incomplete (Figure 10.29).

Figure 10.29: Replica of cranial fragment from Avenis long barrow with incomplete trepanation of the "grooved" type (red arrow) (Photograph property of Stroud Museum, used with permission).

A probable adult male from Winterbourne Monkton (# EU.1.5.042) has evidence of a likely trepanation of the rectangular intersecting type on the right frontal, giving a TPR of 0.6% (1/174). The trepanation measures 25mm supero-inferiorly and 15mm medio-laterally, and appears to be an attempt at a deliberate intervention to gain access into the cranial vault. The ectocranium has been excised away to reveal the diploe beneath, but the procedure has not been concluded, leaving the endocranial layer intact (Figure 10.30). The fact that the site of injury shows no sign of healing, may indicate that this individual died during the procedure, rendering the completion of the operation unnecessary.

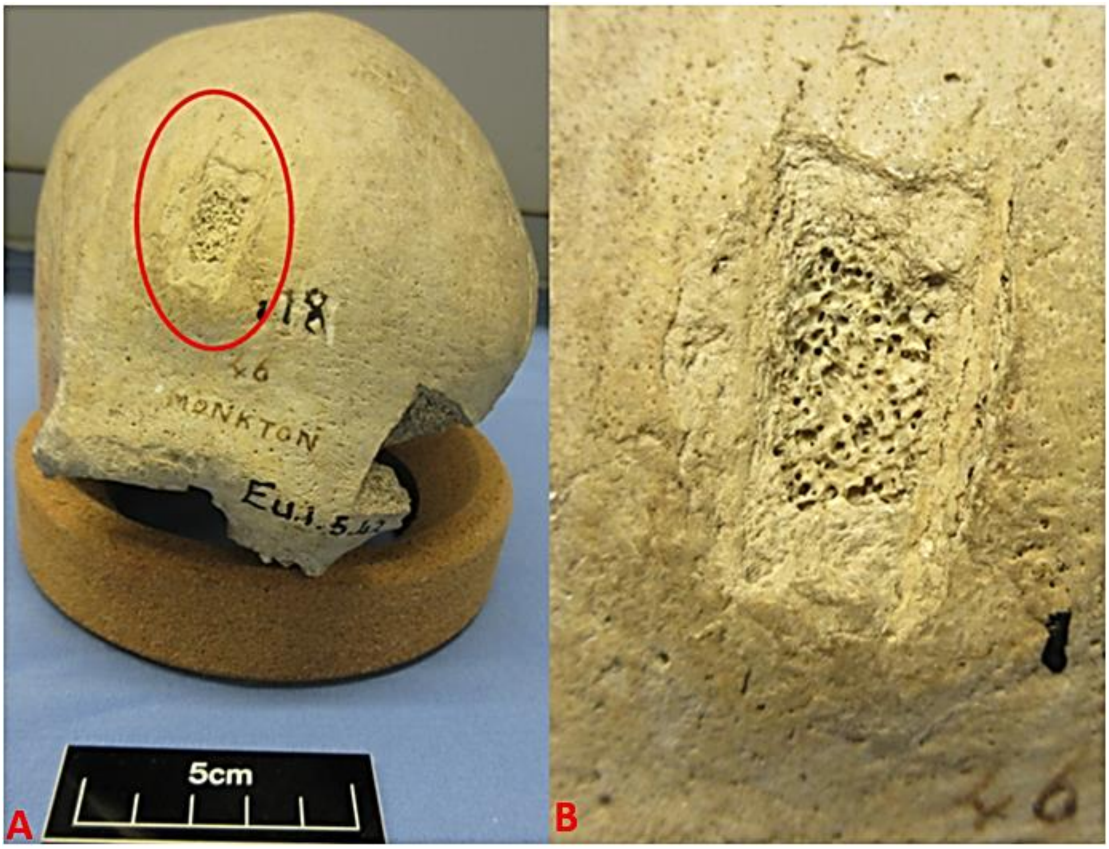


Figure 10.30: A - A probable adult male from Winterbourne Monkton (# EU.1.5.042) with evidence of a partial trepanation of the rectangular intersecting type (red circle). B – Detail.

Another probable adult male from Oldbury Hill long barrow (# EU 1.5.77) exhibits evidence of a possible trepanation to the left parietal, giving a TPR of 0.6% (1/164). The cranial vault has been pierced and an oval shape measuring approximately 45mm supero-inferiorly and 55mm medio-laterally on the outer margin of the wound (which measures 25mm supero-inferiorly and 40mm medio-laterally on the inner margin) has been removed. The trepanation may have been produced using the scraping method, and could possibly have been performed following a blow to the head, which had caused radial fractures (Figure 10.31, red arrows). The wound shows a bevelled appearance around the edges, with exposure of the diploe, but no sign of healing, indicating that the individual did not survive the procedure, or died shortly afterwards. Alternatively, the injury to this individual may not represent a trepanation. The trauma to the cranium may have been produced by sharp force trauma, which would have been delivered by a very sharp implement in a downwards movement, effectively slicing off a large fragment of the left parietal, and causing the radial fractures. In either scenario, the individual did not survive, as there is no sign of healing to the bone.

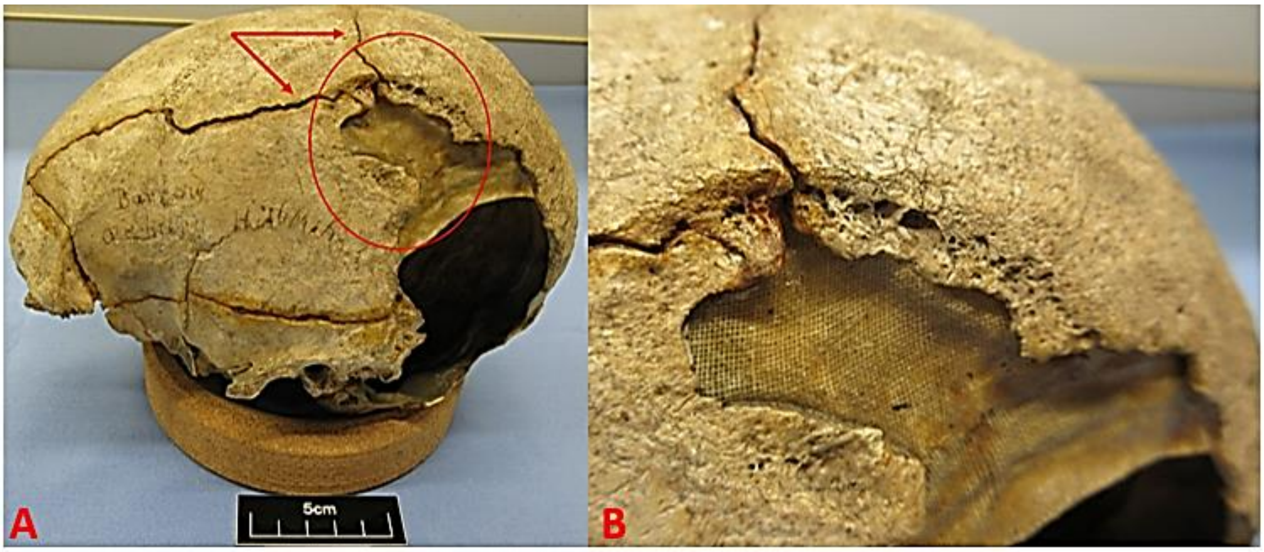


Figure 10.31: A – Probable adult male from Oldbury Hill long barrow (# EU.1.5.77) exhibiting trepanation to left parietal (red circle), and radiating fractures (red arrows). B – Detail.

10.5: Summary

This chapter has outlined the traumatic injuries sustained in the form of fractures, soft tissue injuries and trepanation by the assemblages in this study. Twenty-six fractures were described from at least 19 individuals (6.2%, 19/305) from ten sites (24%, 10/42).

There was a slight bias in the number of males versus females affected by injuries in the current study: nine males and one probable male (39%, 10/26), compared to five females and three probable females (31%, 8/26), although six of the injured bones were unable to be allocated to either sex, and the two remaining cases were of unsexed sub-adults.

Four new cases of cranial trauma were detailed, bringing the total to eight individuals who had suffered blows to the head as a probable result of violence. More males than females were affected (four males and three females, and one unsexed adolescent). Four out of the five cases (80%) of the peri-mortem cranial trauma were inflicted on the left side of the skull, on the parietal bone. This may suggest that the majority of the attacks were carried out from behind by right-handed assailants. In contrast, all of the healed cranial trauma cases were inflicted upon the right side of the head on the frontal bone, suggesting face-to-face attacks.

The elderly female from Lanhill long barrow suffered a broken nasal bone, delivered by a blow to the side of the nose. In addition, she also had a triple fracture of the right zygomatic arch. Considering that these types of injuries either occur as a result of assault, or in modern populations, from sporting injuries or car accidents, it can only be assumed that this individual was a victim of an assault, either on one occasion (as both of the fractures are well-healed), or at least twice. The other two individuals from this study who have also received blows to the face, resulting in a fractured zygomatic bone, are also probably victims of assault.

The remaining cases of fracture in the current study may have been as the result of accidents, and all of the bones have healed, although in many cases, with a degree of displacement. However, the fractured humerus from Rodmarton is considered to have been a peri-mortem injury. Whether it was caused by violence at or around the time of death is unclear, as this was a disarticulated bone and examination of the rest of the skeleton was not possible.

Soft tissue injuries were present on five bones from two sites (4.8%, 2/42), with at least two individuals affected (0.7%, 2/305). Three cases of myositis ossificans traumatica were evident in the assemblages, which are injuries sustained when tendinous or muscle insertions into the bone are damaged, causing a haematoma which calcifies and can eventually ossify. Four cases of cortical defects to the proximal humerus were reported, but in two cases, the damage was evident on the bones of young adult men, on whom the trait is a normal variant which gradually disappears with age (Mann and Hunt 2005: 125). However, two older individuals were reported to have this defect, the causes of which have been ascribed to several different processes: as expressions of repeated stress on the muscle insertion sites; the perduration of a metaphyseal gap; bone tearing during trauma; or erosive calcifying enthesopathies of the muscle insertions (Villotte 2009: 391).

Three individuals from three different sites (7%, 3/42) had evidence of trepanation on the cranial vault, representing 1% of the assemblage (3/305). This is a surgical procedure to gain access to the brain by removing a fragment of bone. Each case of trepanation was attempted using a different method: grooving; intersection; and the scraping method. In all cases however, the recipient did not survive the procedure, as there was no evidence of healing.

Chapter 11: Congenital and Developmental Disorders.

11.1: Introduction

Congenital defects or disorders are those abnormalities that can be detected at birth, but developmental disorders are those that gradually become apparent during childhood and adolescence, with congenital defects accounting for 50% of disorders, and the other 50% appearing gradually over time (Barnes 1994: 1-9). Such abnormalities are a result of pathological changes to the developing foetus, and may be genetic (intrinsic factors) or caused by teratogens (environmental, or extrinsic factors), or a mixture of the two (Schoenwolf *et al*. 2009: 177). The majority (90%) of congenital or developmental disorders are genetically affected, and can be single gene disorders, chromosomal disorders, or most frequently, multifactorial disorders (Sadler 2015: 126). Extrinsic factors can affect either parent before fertilization has taken place, such as being exposed to radiation, or affect the developing foetus, through viral infections contracted by the mother (rubella, for example), maternal hormonal imbalances, nutritional deficiencies, or use of drugs (thalidomide, anti-epileptic drugs etc.) and alcohol, smoking, obesity, or through uterine constraint (Graham and Sanchez-Lara 2016: 8; Geordan *et al.* 2014: 1355; Salter 1999: 133).

Congenital and developmental defects can range from minor disturbances to major abnormalities and can affect any tissue in the body (Barnes 1994: 9). It is during the first eight weeks following conception that the membranous axial skeleton develops, and this is the crucial period within which most congenital and developmental disorders occur (Sadler 2015: 127). Morphogenesis is driven by regulatory genes that set in motion a complex sequence of actions that result in the formation of primordial tissues, and any disruption of the genetic signals gives rise to variation in skeletal tissues (Barnes 2012a: 2). The timing of threshold events which control normal sequential development are crucial, and if delayed or disordered, will result in abnormal development (Barnes 2008: 329). If the notochord, which makes up the framework for the developing axial skeleton, undergoes severe defective development, disorganisation of the embryonic tissues follows, creating a nonviable foetus (Barnes 2012b: 384). However, minor disturbances, or expressions of major defects that do not threaten life, may be studied in past populations and may provide insights into familial relationships, cultural practices and environmental influences

(Barnes 1994: 5). Whilst some of the non-life threatening disorders or defects can affect bodily function in some way, many do not, allowing a degree of variability through evolution that does not become incompatible with life (Barnes 2012b: 380).

<u>11.2: Congenital and Developmental Disorders of the Axial Skeleton</u>

11.2.1: Cranial Vault Anomalies

Extra Ossicles

Extra ossicles, or Wormian bones, are formed within the sutures of the cranium as a result of the delayed approach of one portion of a cranial bone’s blastemal precursor to another, necessitating the formation of an extra ossification centre to fill the gap (Sanchez-Lara *et al*. 2007: 3248). These anomalies are non-life threatening but are of interest to anthropologists as there is a degree of heritability in the phenomena (Berry and Berry 1967: 361). Fourteen individuals (three males, four probable males, five females, one probable female, and one child) from seven sites exhibited extra ossicles (Table 11.1), giving a CPR of 4.6% (14/305) and a TPR of 12% (14/117 whole crania). When the TPR is adjusted for sex, the prevalence rate for females and probable females is 18.2% (6/33) and 15.9% (7/44) for males and probable males.

Table 11.1: Individuals with extra ossicles.

Site	Sex	Lambdoid	Coronal	Apical	Sagittal	Bregmatic	Asterionic	Parietal	Epiteric
Belas Knap # 10	M	✓							
Belas Knap # A1	M?	✓							
Belas Knap # 11	F?		✓						
Belas Knap # civ	M							✓	
Belas Knap # DI	F								✓
Tilshead Old Ditch	F	✓						✓	
Littleton Drew # 54	M?			✓					
Littleton Drew # 59	F			✓	✓				
Littleton Drew # 60	F				✓				
Gatcombe Lodge	M			✓	✓			✓ x 2	✓
West Kennet # 62	M?			✓					
West Kennet # 145	child					✓			
Winterbourne Monkton # 29	M?						✓		
Winterbourne Monkton # 32	F						✓		

It is evident from Table 11.1 that one individual in particular exhibits more extra ossicles than the other individuals. The adult male from Gatcombe Lodge has five extra ossicles (apical bone, sagittal ossicle, left and right parietal notch bones, and the Epiteric bone). Two other individuals have two extra each – an adult female from Tilshead Old Ditch has a lambdoid ossicle and a parietal notch bone, and another adult female from Littleton Drew (#59) has an apical bone and a sagittal ossicle. However, the individual from Gatcombe Lodge also exhibits enlarged mental and infraorbital foramina (Figure 11.1), a diamond-shaped and enlarged foramen magnum, condylar canals (left and right side), an incomplete foramen spinosum (right side), and a precondylar tubercle on the occipito-cervical border (Figure 11.2A and 11.2B), which is a para-axial mesoderm developmental defect, indicative of a minor expression of cranial border shifting (Barnes 1994: 82). In addition, this individual has a retained metopic suture (Figure 11.1). When an individual displays a pattern of anomalies derived from a disturbance of a *single* developmental field (such as the extra ossicles on the cranial vault and the unfused metopic suture), this is called a polytopic field defect (Spranger 1982: 162). However, when a suite of developmental field defects are expressed in one individual, this is more indicative of a syndrome (Spranger 1982: 163). Unfortunately, the individual from Gatcombe Lodge is only represented by a cranium and mandible, thereby rendering further investigation of a differential diagnosis impossible.

Figure 11.1: Adult male from Gatcombe Lodge long barrow, exhibiting enlarged mental and infraorbital foramina (red arrows), and retained metopic suture (blue arrow).

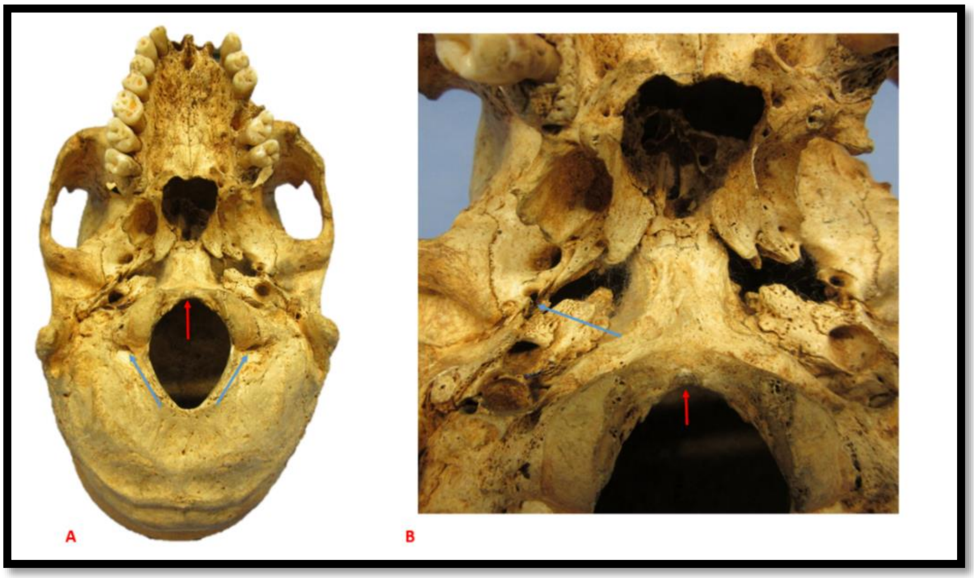


Figure 11.2: A – Adult male from Gatcombe Lodge long barrow, showing condylar canals (blue arrows), enlarged and diamond shaped foramen magnum, and precondylar tubercle (red arrow). B – Detail of precondylar tubercle (red arrow), and incomplete foramen spinosum (blue arrow).

Extra Sutures

Failure of the metopic suture to fuse is caused by developmental delay of the precursors of the frontal bone during the blastemal stage, and can occur as a single field defect or as part of a polytopic field defect (Barnes 1994: 148). The suture usually fuses within the first two years of life, but is retained in some individuals and can be completely unfused or partially fused (Berry and Berry 1967: 367; Barnes 1994: 148).

Four individuals in the current study were found to have a retained metopic suture, giving a CPR of 1.3% (4/305) and a TPR of 2.3% (4/171), which when adjusted for sex is 3% (2/66). An adult male from Gatcombe Lodge, featured in Figure 11.1; an adult male from West Kennet (# EU 1.5.140); a probable male from West Kennet (# EU 1.5.062); and a probable male from Winterbourne Monkton (# EU 1.5.029), and in all cases except one (West Kennet # EU 1.5.140), the individuals had at least one extra ossicle (see Table 11.1). However, the cranium belonging to the male individual from West Kennet (# EU 1.5.140) has suffered severe fragmentation, followed by heavy reconstruction with plaster, so any extra ossicles would have been obscured.

Retention of the mendosa suture occurs when the interparietal and supraoccipital portions of the occipital bone fail to unite (Barnes 1994: 142). This suture or line, usually disappears before birth, but where retained, can be complete or incomplete, and resembles a large interparietal occipital bone, commonly called the Inca bone, due to its high prevalence among South American Native Americans (Barnes 2012a: 11; Barnes 1994: 142). Only two individuals in the current study had a retained mendosa suture – an adult male from Lanhill long barrow (# EU 1.5.104), and probable male from Littleton Drew (# EU 1.5.054) who also has an apical bone, giving a CPR of 0.6% (2/305) and a TPR of 2.3% (1/44).

Sutural Agenesis

The failure of sutures to develop between opposing membranous cranial segments is called sutural agenesis (Sadler 2015: 147; Resnick 2002: 4505). In order for the developing brain to grow, the cranial sutures need to form and remain unfused to allow expansion of the neurocranium (Opperman 2000: 474). Sutural agenesis can be recognised in a neonate and may involve one or more sutures, either completely or partially, resulting in cranial deformity (Barnes 1994: 152). The most common form of sutural agenesis is scaphocephaly, which involves the failure of the sagittal suture, producing an elongated and narrow cranium with a prominent forehead (Sadler 2015: 148; Graham and Sanchez-Lara 2016: 201). This defect does not affect the neurologic function of infants or toddlers, but older children may suffer moderate speech and language difficulties, with up to 50% having mild neurocognitive deficits (Graham and Sanchez-Lara 2016: 202).

Only one individual from the current study exhibited evidence of sutural agenesis – a female aged between 17 and 25 years, from West Kennet long barrow (# EU 1.5.148), giving a CPR of 0.3% (1/305) and a TPR of 3% (1/33). This individual has a long, narrow cranial vault, and completely lacks a sagittal suture, consistent with scaphocephaly (Figure 11.3).

Figure 11.3: Young adult female from West Kennet long barrow (# EU 1.5.148) with scaphocephaly (left - lateral view, right – superior view).

Congenital Muscular Torticollis

Congenital muscular torticollis, also known as wryneck deformity, is associated with a complicated birth and is caused by a shortening of *M. sternocleidomastoid* on one side of the cranium which tilts the head towards the affected side, and rotates it toward the opposite side (Skinner *et al.* 1989: 26; Salter 1999: 171). The muscle becomes fibrous and scar tissue is formed, caused by a combination of traction and twisting during difficult births, such as those born in a breech position, which necessitates a speedy delivery (Skinner *et al*. 1989: 26). This condition also occurs *in utero* as a consequence of abnormal fetal positioning, or due to early descent of the fetal head into the pelvic inlet (Graham and Sanchez-Lara 2016: 143; Nilesh and Mukherji 2013: 198). In modern clinical cases, 90% of neonates respond to stretching exercises to correct the deformity, but if not treated within the first year following birth, the fibrous muscle will need surgical intervention (Salter 1999: 172). Congenital muscular torticollis may be recognised in archaeological specimens by observing the following: twisting of cranial vault to affected side; twisting of cranial base; asymmetry of mandibular fossae; asymmetrical mastoid processes; uneven, or dropped orbit on affected side; deviation of ascending ramus of mandible on affected side; and increased muscle-markers on the *M. sternocleidomastoid* attachment on the clavicle of the affected side (Graham and Sanchez-Lara 2016: 143; Douglas 1991: 266).

One individual in the current study presents with a possible case of congenital muscular torticollis, which has previously been unreported, giving a CPR of 0.3% (1/305) and a TPR of 2.3% (1/44). The adult male from Wor Barrow (Skeleton # 4), aged between 33 and 49 years of age at death, has a twisted cranial vault to the right side, twisting of the cranial base to the right side, asymmetrical occipital condyles, mastoid processes, and mandibular fossae (Figure 11.4). The individual also has a deviated ascending ramus of the mandible on the right side (Figure 11.5B). It is difficult to judge whether the facial features are also asymmetrical, as the lateral border of the right orbit, zygomatic and part of the maxilla are missing (Figure 11.5A). The clavicles show no sign of an exostosis, but the right bone measures (133mm) only 1mm longer than the left (132mm) which is missing its sternal end. The right clavicle is also more curved anteriorly posteriorly than the left, and measures slightly more circumferentially (36mm) than the left (35mm), suggesting that this side of the body was under more muscular strain than the other. Unfortunately, none of the vertebra are extant, which would be useful to determine the diagnosis of this disorder. However, the cranium has a definite, if subtle, twist to the right side, suggesting congenital muscular torticollis. Artificial deformation of the cranium of babies often seen in prehistoric populations, but notably not British examples, could be considered a cause of this condition, together with posthumous plagiocrany, the distortion of skulls from damp soils (Wells 1967: 6) but the other individuals from the long barrow are not similarly affected.

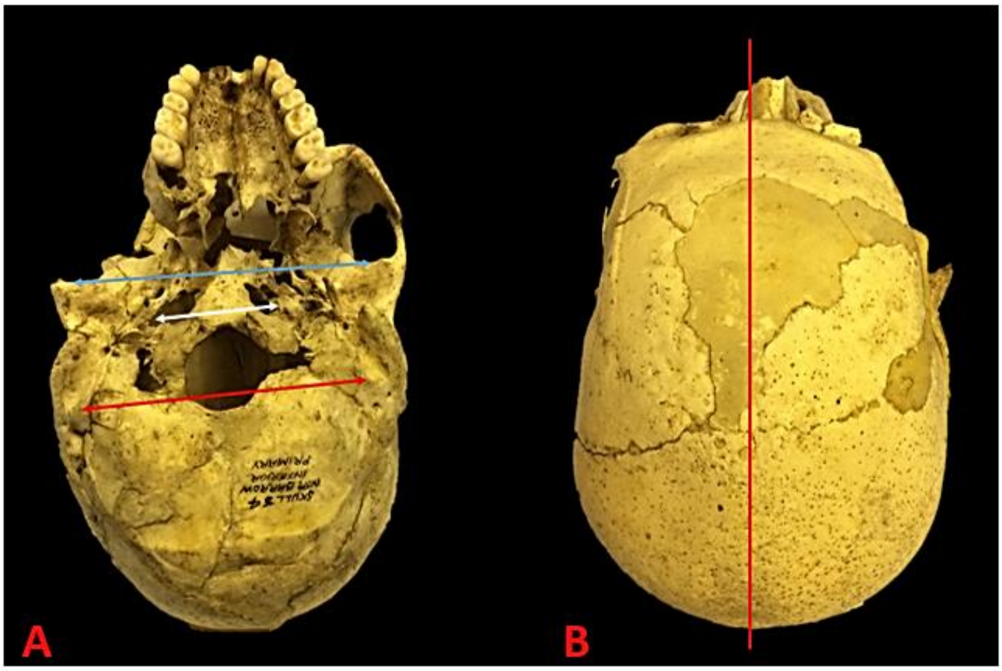


Figure 11.4: A - cranial base of adult male from Wor Barrow (#4), with asymmetry of the mastoid processes (red line), occipital condyles (white line), and mandibular fossae (blue line). B – Cranial vault twisted to the right side.

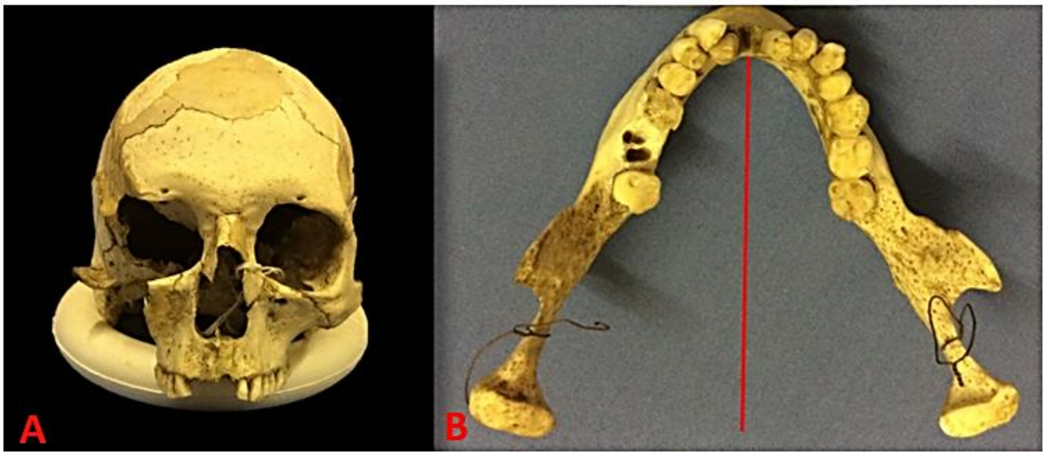


Figure 11.5: A - Adult male from Wor Barrow (#4) with undiscernible facial asymmetry. B – Mandible with deviated ascending ramus on the right side.

11.2.2. Vertebral Column

Three developmental fields affect the developing structures of the vertebral column: the notochord, which provides the framework for the developing tissues, and is a rod-like structure surrounded by a thick membranous layer, around which the precursors of the centra develop; the neural tube, which develops into the structures of the central nervous system; and the paraxial mesoderm columns, which develop from mesenchyme which runs parallel to the notochord, and span the emerging neural tube (Barnes 2008: 340).

Klippel-Feil Syndrome

This disorder is characterised by the congenital fusion of at least two cervical vertebrae, in which there is only one spinous process, body, and neural arch, and is caused by segmentation failure of the spine between the third and eight week of morphogenesis (Gallagher *et al.* 2015: 205; Resnick 2002i: 4602). Klippel-Feil Syndrome may be classed into different categories: Type I, which involves several cervical and upper thoracic vertebrae which fuse into a mass block, and is associated with other major developmental defects; Type II, which only involves two or three vertebral segments, most commonly the second and third cervical vertebrae; and Type III, which involves cervical block vertebrae but with coexisting fusion of some of the thoracic and lumbar vertebrae (Kaplan *et al*. 2005: 573-4). Patients with the disorder may have a shortened neck and a diminished ability in movement (Schoenwolf *et al.* 2009: 231).

Two individuals from two different sites exhibited this developmental disorder, giving a CPR of 0.6% (2/305) and a TPR of 3.9% (2/51). Both individuals were only represented by two fused cervical vertebrae (Type II), and could not be assigned to a specific skeleton. One adult is from Hazleton North long barrow (#7365) and has fusion between the second and third cervical vertebrae (Figure 11.6). The other individual is an adult from Nympsfield long barrow (# 2020), and also has fusion between the second and third cervical vertebrae (see Chapter 8, Figure 8.2 – this individual also has eburnation on the odontoid process of the second cervical vertebra).

Figure 11.6: Adult from Hazleton North long barrow (#7365) with Type II Klippel-Feil Syndrome of the second and third cervical vertebrae. Left – Lateral view, right – anterior view.

Sacralization of Fifth Lumbar Vertebra

Sacralization of the fifth lumbar vertebra occurs when the last lumbar vertebra is incorporated into the sacrum, thereby reducing the number of lumbar vertebrae to four, and producing a longer sacrum with five foramina instead of four (Bron *et al*. 2007: 687). This defect is caused by cranial shifting at the lumbosacral border, and may be complete, unilateral, bilateral, symmetrical, or asymmetrical – bilateral symmetrical assimilation into the sacrum is the least common form and is asymptomatic (Barnes 1994: 110). Conversely, unilateral, or asymmetrical sacralization causes rotation and curvature of the lower back, and may lead to scoliosis (Barnes 2012: 68). Patients may experience low back pain and sciatica and have an increased risk of degeneration to the intervertebral discs or disc herniation (Bron *et al*. 2007: 687). Conflicting prevalence rates for sacralization of the lumbar vertebra have been reported in the literature, with Mahato (2010: 611) giving a rate of 7.5% of the Indian population with the condition, and Bron and colleagues (2007: 690) reporting figures of between 4% and 35% from the literature, which include studies from all over Europe, America, and Israel.

Two individuals from the current study exhibited sacralization of the fifth lumbar vertebra, giving a CPR of 0.6% (2/305) and a TPR of 5.7% (2/35). When the TPR is adjusted for sex, the rate for females is 11% (1/9) and 6.25% for males (1/16). An adult female from Lanhill long barrow (# EU 1.5.107) has a bilateral symmetrical sacralization that is completely assimilated (Figure 11.7a). However, an adult male from Hazleton North long barrow, Skeleton D, has unilateral, asymmetrical sacralization of the fifth lumbar vertebra, which has not fused on the right side, causing the sacrum to lean laterally on the left side (Figure 11.7 b and c). The transverse process on the right side looks ala-like and has a bifurcated appearance. This individual would likely have had suffered curvature of the lower back, and perhaps scoliosis of the spine, but unfortunately no vertebrae are extant. However, this individual is considered to also have possibly suffered from polio (see Chapter 7) and has a longer left femur (461mm) than the right (455mm), but whether this is due to infectious causes or as compensation for a left-leaning sacrum is unclear.

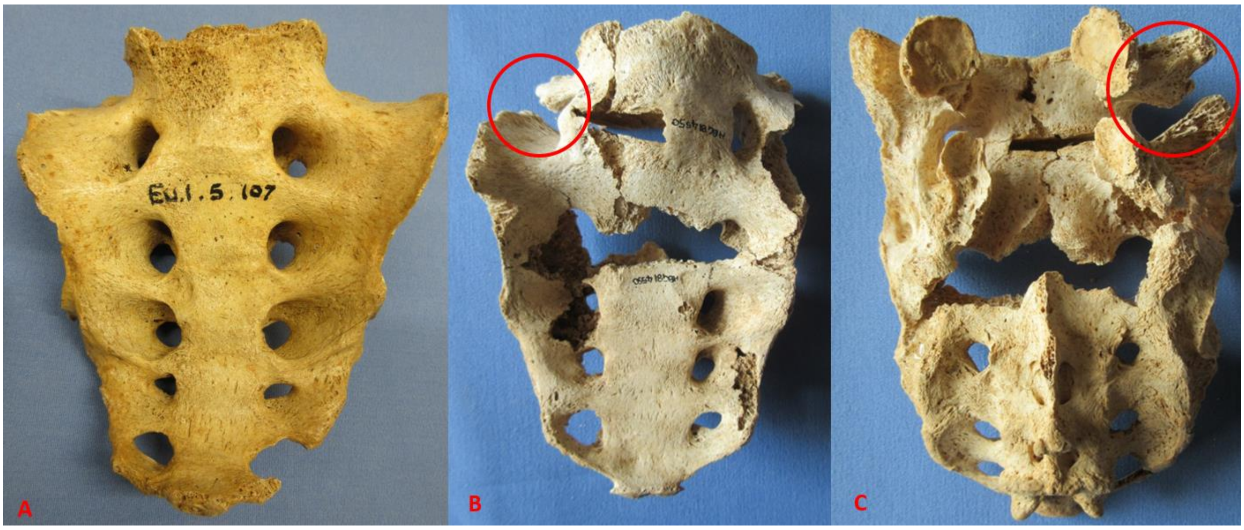


Figure 11.7: A – Adult female from Lanhill long barrow (# EU. 1.5.107) with complete bilateral symmetrical sacralization of the 5th lumbar vertebra. B – Anterior view of adult male sacrum from Hazleton North long barrow (# 4550, belonging to Skeleton D) with unilateral and unsymmetrical sacralization of the fifth lumbar vertebra, and bifurcated transverse process (red circle). C - Posterior view.

Spina Bifida Occulta

Spina bifida occulta is a neural tube defect that affects the closure of the neural arches in the sacrum, leaving the posterior of the sacrum (the sacral crest) open (Waldron 2009: 219). Unlike the more serious form spina bifida cystica, the meningeal fibres do not protrude from the open crest and are normally covered by fibrous tissue, and do not usually affect the quality of life for the affected individual (Aufderheide and Rodríguez-Martin 2011: 61). This defect occurs in approximately 2% of modern populations and whilst the condition is asymptomatic, the area on the lower back may be marked by a tuft of hair, a mole, an angioma (a port-wine birth mark), a lipoma (underlying mass of fatty tissue) or a dimple (Schoenwolf *et al*. 2009: 113). Another form of developmental defect that affects the vertebrae and sacrum and mimics spina bifida occulta, is clefting of the vertebrae without neural tube defect, as both defects include partial or incomplete closure of the sacral crest (Barnes 1994: 49). Differentiating between the two defects is difficult, but spina bifida occulta may be recognised by a widened sacral canal, which pushes the borders of the cleft outwards. Conversely, clefting without neural tube defect produces a normal sacral canal, with the edges of the cleft remaining flat, but with irregular borders (Barnes 2012a: 80).

One individual from the current study manifests spina bifida occulta to the sacrum, giving a CPR of 0.3% and a TPR of 2.9% (1/35). The adult individual from Luckington long barrow (# GC/D/5) is represented by this element only and exhibits an open sacral canal between S2 and S5, which widens inferiorly, and has borders that splay posteriorly (Figure 11.8a). In contrast, an adult female from West Kennet (Skeleton X), exhibits clefting of the sacral canal without neural tube defect (Figure 11.8b). Here, the cleft is complete, affecting S1 to S5 but the borders are flat and irregular.

Figure 11.8: A – Adult from Luckington long barrow (# GC/D/5) with spina bifida occulta between S2 and S5. B – Adult female from West Kennet long barrow (Skeleton X) with clefting of the sacral canal without neural tube defect.

Sternum

The sternal plates develop from mesenchymal bands which fuse in sequence from the cranial to caudal ends between the seventh and tenth week of embryonic growth (Barnes 1994: 210). Once the cartilaginous framework is formed, the fused sternal bands form into four sternebrae below the manubrium, which gradually fuse together (Barnes 2012a: 109). Delayed or incomplete caudal fusion of the mesosternum can cause defects that range from hyperplasia, fissures and clefts which are asymptomatic (Sadler 2015: 154). Incomplete caudal cohesion of the sternal bands is more common between the third and fourth sternebrae, producing a sternal aperture, consisting of a round or oval hole, which is caused by a lack of fusion between the sternal bands at this junction (Barnes 2012a: 117). One adult from West Kennet long barrow, excavated from the SE chamber (un-numbered) exhibits this developmental defect, giving a CPR of 0.3% and a TPR of 2.9% (1/34) (Figure 11.9).

Figure 11.9: Sternal aperture in an adult from West Kennet long barrow.

11.3: Congenital and Developmental Disorders of the Appendicular Skeleton

11.3.1 Upper Limb

Humerus

Morphogenesis of the limbs occurs between the fourth and eighth week, and by the end of this short period, the embryonic membranous skeleton is complete, making way for the developing bony skeleton and ossification via cartilaginous and membranous pathways (Barnes 2012a: 123, 6). During the eight week of embryonic development, primary ossification of the humeral diaphysis takes place, but the epiphyses remain cartilaginous until specific developmental thresholds have been reached: the proximal humeral head begins to ossify within the first year following birth; ossification of the greater and lesser tubercles begins within the third and fifth years respectively, uniting with the proximal humeral head by the sixth year to form a single epiphysis which finally unites with the diaphysis by the twentieth year (Cunningham *et al*. 2016: 294). The distal humerus is formed from four ossification centres: the first appearing during the middle of the first year, with the trochlea and lateral epicondyle ossifying between the 13th and 14th year; the three ossification centres unite, and fuse with the diaphysis by the 17th year; the medial condyle fuses onto the diaphysis last, at the age of about 18 years (Barnes 2012a: 130-131). Developmental disorders of the upper limb can affect the whole limb, but are normally only minor variants, but where fusion disorders occur, they are usually found in the forearm (Barnes 2012b: 396).

Supracondylar Process

The supracondylar process or supratrochlear spur is a small bony triangular spur that forms approximately 5cm above the medial epicondyle of the humerus (Barnes 2012a:131). The spur houses an accessory attachment for *M. pronator teres*, producing a fibrous tunnel through which the median nerve and brachial artery pass, and which may cause neuro-vascular impingement (Mann and Hunt 2005: 125). This trait is thought to be hereditary and has been found in neonates and even in embryos (Adams 1934: 316).

One individual in the current study exhibited a supracondylar spur, giving a CPR of 0.3% and a TPR of 7.1% (1/14). The individual, a young male adult, aged between 15 and 23 years old (based on epiphyseal fusion) from Wor Barrow (# 3), has a supracondylar spur on the distal right humerus (Figure 11.10).

Figure 11.10: A young adult from Wor Barrow (# 3) with a supracondylar spur on the distal right humerus (red arrow).

Septal Aperture

Septal aperture, olecranon perforation, or supratrochlear foramen is a perforation found in the olecranon fossa, and can range in size from a pinpoint, to a large foramen (Bass 2008: 148). The septal aperture is caused by incomplete ossification of the fragile wall that separates the olecranon and coronoid fossae, leaving the void to be filled with fibrocartilaginous tissue that does not ossify (Barnes 2012a: 131-2). This trait can be unilateral or bilateral, is more common in females and the left humerus is more frequently affected (Mays 2008b: 439).

Two humeri in the current study exhibited a septal aperture. Both elements were excavated from Luckington long barrow, and came from a commingled mass of bones. The two bones (a left and a right) were found in the same context (GC/D/1) and measure different lengths but have a similar diameter of the humeral head and epicondylar width (Table 11.2). The bones may therefore come from the same individual, giving a CPR of 0.3% (1/305) and a TPR of 1.4% (1/71) for the right humerus and 1.4% (1/71) for the left humerus. Both apertures are fully formed, with smooth edges (Figure 11.11).

Table 11.2: Measurements of two humeri found in context GC/D/1.

Humerus	Left	Right
Length mm	**294**	**277**
Head Diameter mm	**35.5**	**36.5**
Epicondylar Width mm	**52**	**51**

Figure 11.11: Left humerus from probable female from Luckington long barrow, with septal aperture (red arrow).

11.4: Summary

This chapter outlined congenital and developmental disorders for the 42 sites in this study. The majority of the defects were recorded in the axial skeleton and 26 individuals (8.5% of the assemblages) had one or more abnormality. Fourteen individuals had extra cranial ossicles, with no significant difference in the male/female ratio of those affected. Two females had two extra ossicles each; the individual from Tilshead Old Ditch had a lambdoid ossicle and a parietal notch bone; the other individual from Littleton Drew (# EU.1.5.059) had an apical bone and a sagittal ossicle. Three individuals had two anomalies derived from a single developmental field. A probable male from Littleton Drew long barrow (# EU. 1.5. 054) had an extra cranial ossicle and a retained Mendosa suture. Two individuals had an extra cranial ossicle and a retained metopic suture: West Kennet long barrow (# EU.1.5.062) had an apical ossicle; and Winterbourne Monkton (# EU.1.5.029) had an Asterionic bone. However, the adult male from Gatcombe Lodge long barrow has a suite of minor abnormalities in the form of several non-metric traits, and defects of two developmental fields, suggesting that this individual may have suffered from a syndrome of some sort. This individual has five extra cranial ossicles and a retained metopic suture, which are field defects of the blastemal desmocranium, and a precondylar tubercle on the occipito-cervical border of the cranial base, which is a para-axial mesoderm developmental defect. The lack of any post-cranial bones has hampered any further investigation into a possible classification of the type of syndrome that this individual may have been suffering from.

Five individuals in the current study had congenital and developmental disorders that would have had an aesthetic and physical impact upon the lives of the affected. The young adult female from West Kennet long barrow (EU. 1.5.148) with scaphocephaly would have had a prominent forehead, and a long and narrow skull, which would have affected her appearance. In addition, she may have had mild mental and behavioural deficits which would also have marked her out as “different” Graham and Sanchez-Lara 2016: 202).

The middle-aged adult male from Wor Barrow (Skeleton # 4) would also have had a noticeable and different appearance from others within the community. This individual probably suffered from muscular torticollis and has a twisted cranial vault that favours the right side, which has also caused the cranial base to turn to the right, affecting the ramus of the mandible on this side. This prolonged muscular deformation has made the cranium and mandible tilt to one side, while lifting the chin on the opposite side and probably resulted in facial asymmetry, and a considerably diminished range of movement in the neck.

The two individuals from Hazleton North long barrow (# 7365) and Nympsfield long barrow (# 2020) suffering from Klippel-Feil Syndrome could also have had an unusual appearance in the form of a shortened neck, which allowed only restricted mobility of the upper spine due to the fusion of the second and third cervical vertebrae. Lastly, the adult male individual suffering from unilateral, asymmetrical sacralization of the fifth lumbar vertebra, Skeleton D from Hazleton North long barrow, would have had scoliosis of the lower spine due to fusion of the vertebra only on the left side, causing a twisted appearance. This deformity would have produced lower back pain and stiffness of movement, and considering that this individual also had a paralysed upper limb likely due to polio, would have made him noticeable within the community.

The last four individuals with congenital or developmental disorders in the current study had minor defects that would have been asymptomatic and would not have affected their daily lives. The adult with spina bifida occulta from Luckington long barrow may have been totally unaware of their condition unless there was a small tuft of hair, or a mole, fatty lump, or birth mark on the lower back, but no other symptoms. Similarly, the adult from West Kennet long barrow with a sternal aperture, the young male adult from Wor Barrow with a supracondylar spur of the humerus, and the adult from Luckington long barrow with a septal aperture of the humerus would have had no reason to believe that they had been born with small defects, as they would have had no mechanical or physical effect on the individuals involved whatsoever.

Chapter 12: Circulatory Disorders

12.1: Introduction

Disturbances of the circulatory system are caused by arterial obstructions which decrease the rate of blood flow to tissues and organs (ischemia) - if the process develops over time, the affected tissue will become atrophied with an overall decrease in volume (Aufderheide and Rodríguez-Martin 2011: 77). However, if the arterial obstruction is sudden, such as in the formation of a blood clot, the cells of the affected tissue cannot survive, and cellular death, or necrosis follows (Ortner 2003: 344). Necrosis of bone cells following total withdrawal of the oxygen supply occurs within 12 to 48 hours (Sweet and Madewell 1995: 3447). If the individual survives the sudden circulatory disturbance, necrotic tissue is dissolved, absorbed, and replaced by fibrous tissue, but if skeletal tissue is involved, a lesion in the vicinity of the bone surface will result in a cortical defect (Aufderheide and Rodríguez-Martin 2011: 77).

12.2: Osteochondritis Dissecans

The aetiology of osteochondritis dissecans is not fully understood. However, numerus causes have been suggested, such as trauma, whether direct or repetitive micro-trauma (Waldron 2009: 153; Schindler 2007: 48), ischemia, leading to avascular necrosis (Salter 1999: 355; Pill *et al*. 2001: 25), and disruption of normal endochondral ossification (Zbojniewicz *et al*. 2012: 1127). Furthermore, it has been suggested by some that genetic influences are a convincing factor in the development of osteochondritis dissecans. Mackie and Wilkins (2010: 896) presented a case of identical twins who both developed the condition in the same anatomical location, and Stougaard (1964: 543) demonstrated that ten members of the second and third generations of one family all developed osteochondritis dissecans. In addition, Lee *et al.* (2009: 2700) presented three cases of bilateral osteochondritis dissecans of the femoral head in multiple members of the same family over several generations. Due to the uncertainty of the aetiology of the condition, Schindler (2007: 48) considers a multifactorial approach to be the most appropriate.

Osteochondritis Dissecans, also known as König’s disease, is characterised by the pathological fragmentation of a small area of subchondral bone and the overlying cartilage in synovial joints (Lee *et al*. 2009: 2700). In consequence, the necrotic fragment (a so-called “joint mouse”) may float loosely within the synovial cavity, and the cartilaginous portion may continue to grow due to the nutrients in the synovial fluid (Schindler 2007: 50: Aufderheide and Rodríguez-Martin 2011: 82). However, the bony component of the fragment does not continue to grow. The defect in the subchondral surface of the bone (a “mouse bed”) may be lightly covered with a thin irregular layer of bone, which never becomes fully level with the adjacent areas, leaving a shallow crater or depression (Ortner 2003: 352: Aufderheide and Rodríguez-Martin 2011: 82). Individuals with this condition may be entirely asymptomatic but where pain is experienced, it may be aggravated by movement, with limited capacity for motion, clicking of the affected joint, locking and swelling (Resnick and Goergen 2002: 2689).

Osteochondritis dissecans usually develops during adolescence and in young adults, and is more common in males than females (Salter 1999: 355). Any synovial joint may be affected, either occurring in one joint or in many, and more commonly on the convex than concave surfaces (Waldron 2009: 154; Resnick and Goergen 2002: 2689). Table 12.1 lists the most common joints affected by osteochondritis dissecans in modern populations – the most frequently affected joint is the knee, with the highest proportion of cases (75%) reported on the lateral aspect of the medial femoral condyle (Waldron 2009: 154).

Table 12.1: Sites of osteochondritis dissecans in modern populations (after Waldron 2009: 154).

Joint Affected	Most Common Sites
Knee	Lateral aspect of medial femoral condyle (75%); weight bearing surface medial condyle (10%); Lateral femoral condyle (10%); anterior intercondylar groove or patella (5%)
Elbow	Anterolateral aspect of capitulum
Ankle	Posteromedial aspect of dome of talus (56%); anterolateral aspect of talus (44%). Navicular may also be affected.
Hip	Femoral head
Shoulder	Rare – occurs on head of humerus and glenoid fossa
Wrist	Rare - scaphoid

In his paper on ancient British skeletal material, Wells (1974) also discusses the most common joints affected by osteochondritis dissecans in past populations, and states that while the lateral aspect of the medial condyle of the femur is also the most common site for the condition in these assemblages, it is less so than in modern populations (Wells 1974: 366). Table 12.2 lists the most commonly affected joints for the condition, which are similar to those listed in Table 12.1, except that in many cases, the site of the lesions are different. In addition, Wells (1964: 366) notes the presence of the condition in the cervical vertebrae, on the apophyseal joints, and in particular, on the axis. Furthermore, 95% of the lesions noted by Wells (1974: 367) occur in the knee or foot.

Table 12.2: Sites of osteochondritis dissecans in past populations (after Wells 1974).

Joint Affected	Most Common Sites
Knee	Medial femoral condyle; lateral femoral condyle (30%); medial condyle tibia 30%; lateral condyle tibia 70%
Elbow	Rare: proximal ulna; anterolateral aspect of capitulum
Ankle	Superior surface of talus; head of talus; subtalar joint of talus (75%)
Hip	Acetabulum (common); femoral head (rare)
Shoulder	Rare – humeral head; glenoid fossa
Wrist	Distal radius at radiocarpal joint
Apophyseal	Cervical vertebrae, especially axis
Talocalcaneonavicular	Anterior and posterior surfaces of navicular
Metatarsophalangeal	Proximal articular surface of 1st metatarsal
Interphalangeal	Head of 1st metatarsal

In the present study, at least six individuals show evidence of osteochondritis dissecans. Seven bones from three sites exhibit the characteristic lesions, but in one case the bones could be from the same individual. Therefore, the CPR for osteochondritis dissecans for all sites is 2% (6/305). The TPR for each element is given in the summary Table 12.3 at the end of the chapter.

An adult male from Haddenham long barrow (Skeleton A) has a small lesion, measuring 2mm medio-laterally x 2.9mm supero-inferiorly on the posterior, or proximal surface of the left navicular. The lesion is a shallow, oval depression, with an irregular lining on the surface of the facet that articulates with the head of the talus (Figure 12.1).

Figure 12.1: Left - Left navicular from an adult male from Haddenham long barrow (Skeleton A), with osteochondritis dissecans in the form of an oval depression on the posterior surface. B – Detail.

Skeleton # 2 from Hazleton North long barrow also exhibits a small lesion in the superior half of the posterior surface of the left navicular. The oval lesion measures 1.6mm medio-laterally x 2mm supero-inferiorly and has an irregular and coarse lining (Figure 12.2).

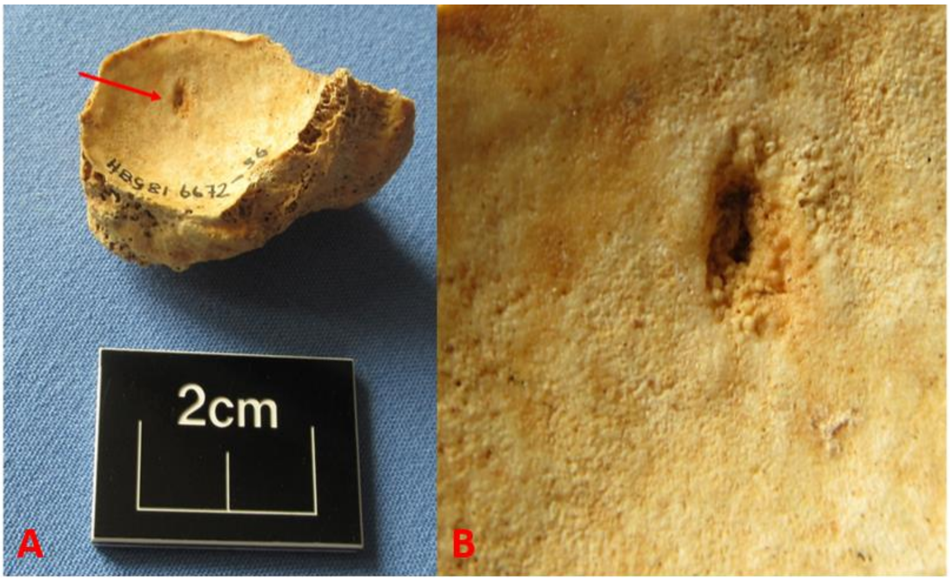


Figure 12.2: A – left navicular from Skeleton # 2 from Hazleton North long barrow, with small lesion to superior half of posterior surface. B – Detail.

An isolated right trapezium, also from Hazleton North long barrow (# 9233) but not belonging to the above individual (who has both the right and left trapezium), has a well-defined circular erosive lesion measuring 1.5mm supero-inferiorly x 1.3mm medio-laterally on the sellar facet for the first metacarpal. The defect has an irregular lining and is adjacent to an area of eburnation (Figure 12.3). The presence of eburnation, together with the contour change of the joint, suggests that this individual had osteoarthritis of the hand (see Chapter 8).

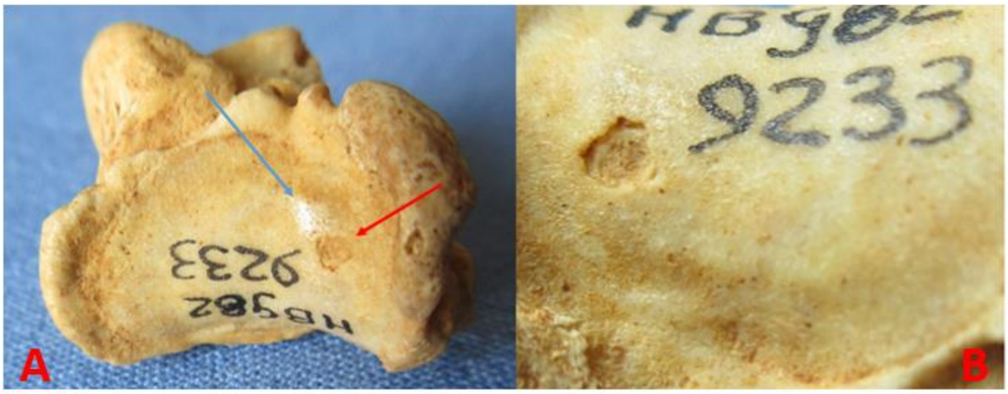


Figure 12.3: A – right trapezium from Hazleton North long barrow (#9233) with osteochondritis dissecans on sellar facet for first metacarpal (red arrow), and area of eburnation (blue arrow). B – Detail.

A juvenile from Hazleton North long barrow, represented only by an isolated axis vertebra (# 9366), has a fairly large oval lesion on the right superior articular facet, which articulates with the atlas, measuring 5.5mm supero-inferiorly x 3mm medio-laterally. The lesion has an irregular lining but seems to be very porotic and disorganised (Figure 12.4). The area surrounding the lesion is also very porous. In addition, the left superior articular facet is also very porotic, therefore this lesion may not be evidence of osteochondritis dissecans, but of some form of non-specific infection of unknown aetiology.

Figure 12.4: A – axis from a juvenile from Hazleton North long barrow (# 9366) with lesion to right superior articular facet (red arrow). B – Detail of lesion and accompanying porosity.

The fourth example of osteochondritis dissecans is from a mature adult male, also from Hazleton North long barrow, and is located on the glenoid fossa of an isolated left scapula (# 8497). It is possible that this element belongs to Skeleton # 2 featured in Figure 12.1, as no scapulae were assigned to this individual, although this is unlikely, as Skeleton # 2 was excavated from the north entrance of the monument, whereas the isolated scapula was excavated from the southern chamber, and there is no evidence of the same individual occurring in both chambers (Saville 1990: 106). The lesion is located in the centre of the glenoid fossa and has well-defined edges, with an uneven lining, and measures 2.3mm medio-laterally x 2.8mm supero-inferiorly (Figure 12.5).

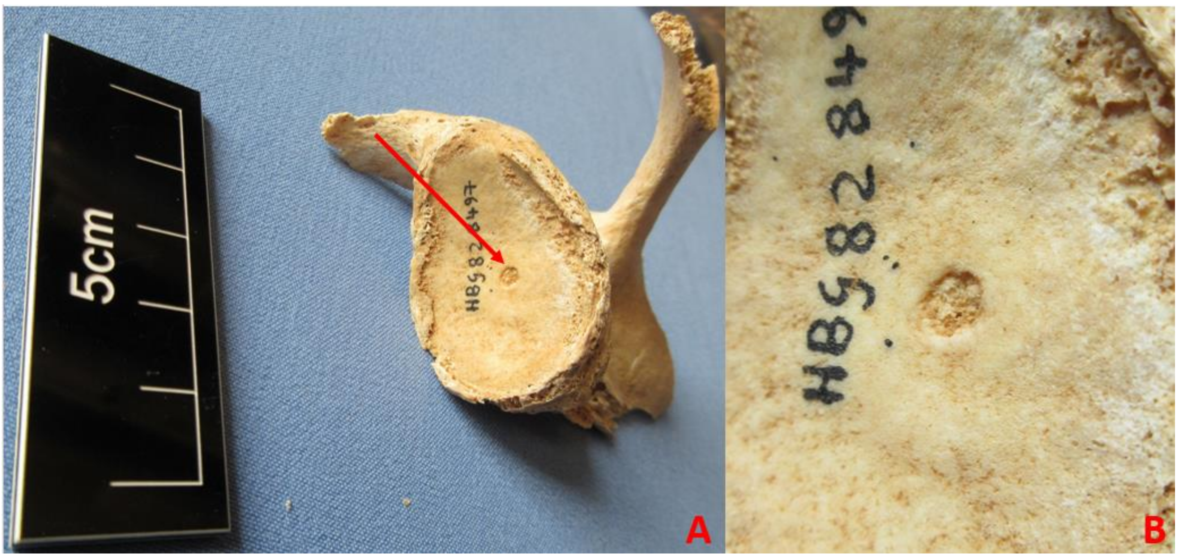


Figure 12.5: A – left scapula from a mature adult male from Hazleton North long barrow (# 8497), with osteochondritis dissecans in the glenoid fossa. B – Detail.

The last two examples of this condition were both excavated from Rodmarton long barrow. No contextual information was available with the assemblage, and as neither element could be assigned sex or age categories, it is a possibility that they belong to the same individual.

An adult left radius from Rodmarton long barrow (no number) exhibits a small oval lesion on the head which articulates with the anterolateral aspect of the capitulum of the distal humerus and measures 3mm medio-laterally x 1.8mm supero-inferiorly. The defect has smooth edges and an uneven lining, and is characteristic of the lesions found in osteochondritis dissecans (Figure 12.6).

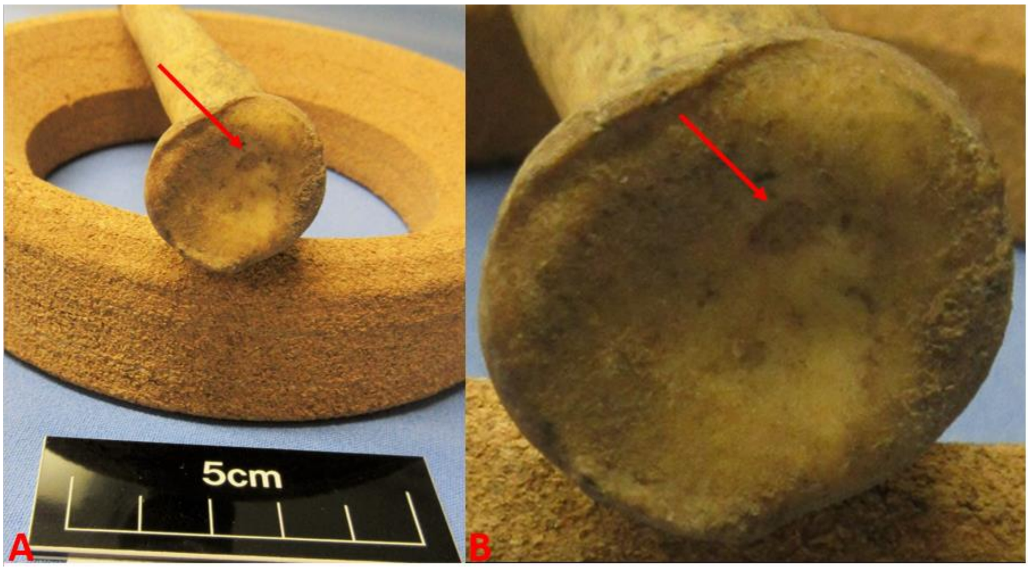


Figure 12.6: A – Left radius of an adult from Rodmarton long barrow, with evidence of osteochondritis dissecans on the radial head. B – Detail.

An adult axis vertebra (no number), also from this site, exhibits bilateral lesions on the superior articular facets (Figure 12.7a). The lesion on the right superior articular facet measures 9mm supero-inferiorly x 6mm medio-laterally, and is an oval defect with clearly defined edges, and an uneven base (Figure 12.7c). The lesion on the left superior articular facet is smaller and measures 4mm supero-inferiorly x 2mm medio-laterally, but the edges are not so clearly demarcated and the lining is less organised than the lesion on the other side (Figure 12.7b).

Figure 12.7: A – Adult axis from Rodmarton long barrow with bilateral osteochondritis dissecans on the superior articular facets. B – Detail of left superior articular facet. C – Detail of right superior articular facet.

12.3 Summary

Table 12.3 lists the elements from three sites that were affected by osteochondritis dissecans, and the TPR for each element.

Table 12.3: Summary of elements with evidence of osteochondritis dissecans.

Site	Element Affected	Side	Age	Sex	TPR %
Haddenham (Skeleton A)	Navicular	Left	Adult	Male	4.6% (2/44)
Hazleton North (Skeleton 2)	Navicular	Left	Mature Adult	Male?	
Hazleton North # 9233	Trapezium	Right	Adult	?	6.3% (1/16)
Hazleton North # 8497	Scapula	Left	Mature Adult	Male	10% (1/10)
Hazleton North # 9366	Axis		Juvenile	?	4% 2/51
Rodmarton	Axis		Adult	?	
Rodmarton	Radius	Left	Adult	?	2.1% (1/47)

There were seven elements from the current study with evidence of osteochondritis dissecans, but because two of these were excavated from the same site (Rodmarton long barrow) without any contextual information, and it was not possible to assign either sex or age categories, it is possible that they belong to the same individual. The number of individuals affected by this condition is therefore six, giving a CPR of 2%. Where it was possible to determine the sex of the affected individuals, more males than females were considered to have osteochondritis dissecans, which conforms to the pattern seen in modern medicine. In addition, in common with both modern and past populations, the posterior surface of the navicular is frequent site for the condition, which in the current study was two cases, or 29% (2/7), with a TPR of 4.6% (2/44). As noted by Wells (1974), the apophyseal joints of the cervical vertebrae, in particular the axis, were found to be a more common site for lesions of this nature in past populations than in those found clinically, which is confirmed by this study which noted that two individuals had lesions in this location (29%, 2/7), and a TPR of 4% (2/51). Furthermore, modern and past population studies have both noted that evidence of lesions affecting the shoulder joint are rare, but this study found one case of osteochondritis dissecans on the glenoid fossa of the scapula, which accounts for 10%

of the total (1/10). Clinical studies and those of past populations do not mention the prevalence of lesions in the humero-radial joint, in particular that of the radial head, but the anterolateral aspect of the capitulum is a common site for the lesions in modern populations, but rarer in past populations. Finally, the location of a lesion on the sellar facet for the first metacarpal of the trapezium is unusual, but could possibly be due to a different disease process, such as osteoarthritis.

Chapter 13: Neoplastic Disease

13.1: Introduction

A neoplasm (new growth) or tumour is defined as "a mass of localized tissue growth whose cellular proliferation is no longer subject to the effects of normal growth-regulating mechanisms" (Aufderheide and Rodríguez-Martin 2011: 371). Neoplasms may be classified as primary or secondary, or as benign or malignant. A primary tumour does not spread around the body and is therefore found in the originating tissue (Waldron 2009: 168). Malignant tumours (cancer) however, originate in one tissue and spread to other areas of the body, via the bloodstream or lymphatic system, producing secondary neoplasms which are inevitably life threatening (Salter 1999: 379).

Today, cancer is a leading cause of mortality, responsible for approximately 29% of all deaths recorded for the year ending 2014 in England and Wales (Office for National Statistics, 2017). Nationally, 163,400 deaths due to cancer were recorded for 2014 (86,500 males and 76,900 females), accounting for 450 deaths per day (Cancer Research UK, 2017). Globally, 8.8 million deaths were recorded due to cancer in 2015, with cancer of the lung, liver, colorectal, stomach and breast the most common (WHO, 2017). Bone cancer accounted for only 1% of new cases diagnosed in 2014 in the UK (580 cases), of which 310 were male patients, and 210 female: 53% of those diagnosed were in the 45+ age category, the highest incidence in those aged 85 or over (Cancer Research UK, 2017). In children, the incidence of primary bone cancer was 60 cases per year (average between the years 1996 and 2005) and 103 cases in juveniles and young adults (average for the years between 2000 and 2009) (Cancer Research UK, 2017). Secondary, or metastatic bone tumours commonly spread to bone, especially those which have a primary origin in the breast, lung, prostate, kidney and thyroid (Waldron 2009: 185; Salter 1999: 381).

The most common forms of cancer diagnosed between the years 1995 and 2004 in children, are leukaemia and brain tumours (and other central nervous system and intracranial tumours), accounting for 110 and 112 deaths per year respectively (Cancer Research UK, Great Britain cancer mortality 1995-2004 summary, 2014). The most common causes of death from cancer in juveniles and young adults (aged between 15-24 years) are from brain cancer and leukaemia, accounting for 63 (36 male and 27 female) deaths, and 59 deaths (36 male and 23 female) respectively

(Cancer Research UK, 2017). Figures released for the average number of deaths per year and age-specific mortality due to cancer (for the years 2012-2014) suggest an increase in incidence with age, with a sharp rise in mortality in those adults aged over 60 years of age, and males accounting for more deaths than females (Table 13.1).

Table 13.1: Average number of deaths per year (2012-2014) and age-specific mortality rates per 100,000 population (data taken from cancer Research UK, 2017).

Age Range	Male Deaths	Female Deaths	Male Rates	Female Rates
0 - 4	47	39	2.3	2.0
5 - 9	47	40	2.4	2.2
10 - 14	38	33	2.1	1.9
15 - 19	64	47	3.2	2.5
20 - 24	87	75	4.0	3.5
25 - 29	131	151	6.0	6.9
30 - 34	210	294	9.8	13.6
35 - 39	319	460	16.0	22.9
40 - 44	678	984	30.6	43.4
45 - 49	1428	1769	61.9	74.6
50 - 54	2557	2853	118.9	129.9
55 - 59	4360	4076	234.7	214.1
60 - 64	7358	6070	422.1	334.3
65 - 69	11089	8696	658.1	488.2
70 - 74	12599	9729	1043.6	724.8
75 - 79	14330	11292	1501.6	991.6
80 - 84	14127	12194	2169.5	1355.9
85 - 89	10455	10253	3031.0	1732.4
90+	5742	7589	3853.3	1989.5
All Ages	85667	76644	271.6	235.2

Statistics for new cases of cancer diagnosed in adult females for 2014 show that breast cancer is responsible for 31% (54,833 cases), followed by lung cancer (12% or 21,634 cases), bowel cancer (10% or 18,421 cases), and the remaining 47% (86,829 cases) from other sites (Cancer Research UK, 2017) (Figure 13.1).

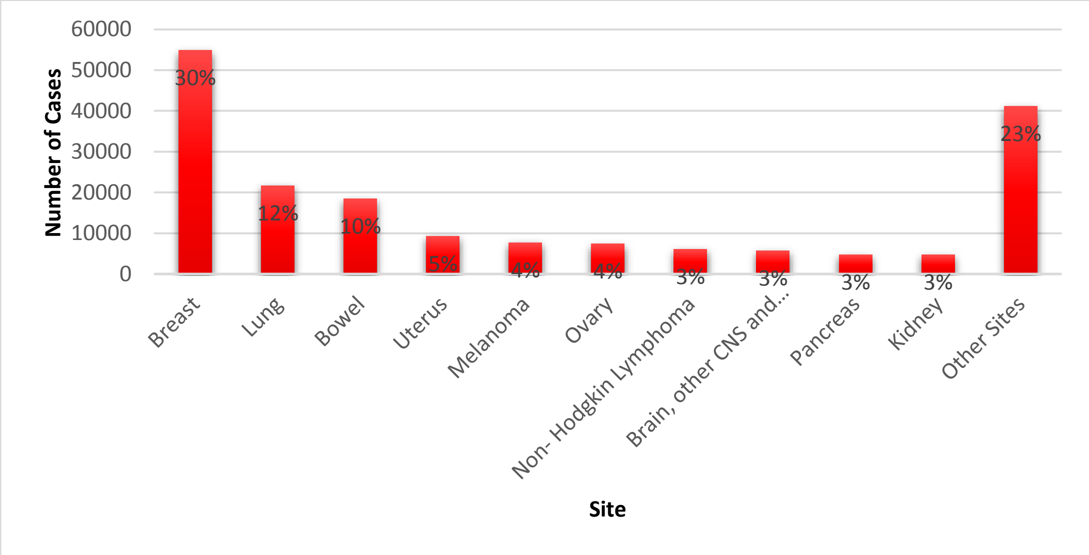


Figure 13.1: Ten most common cancers in females 2014 (data: Cancer Research UK, 2017).

New cases of cancer for adult males for the same year show that prostate cancer is the most common form diagnosed, accounting for 26% of cases (46,690 individuals), followed by lung cancer (14% or 24,769 cases), bowel cancer (13% or 22,844 cases), and the remaining 47% (86,533 cases) from other sites (Cancer Research UK, 2017) (Figure 13.2).

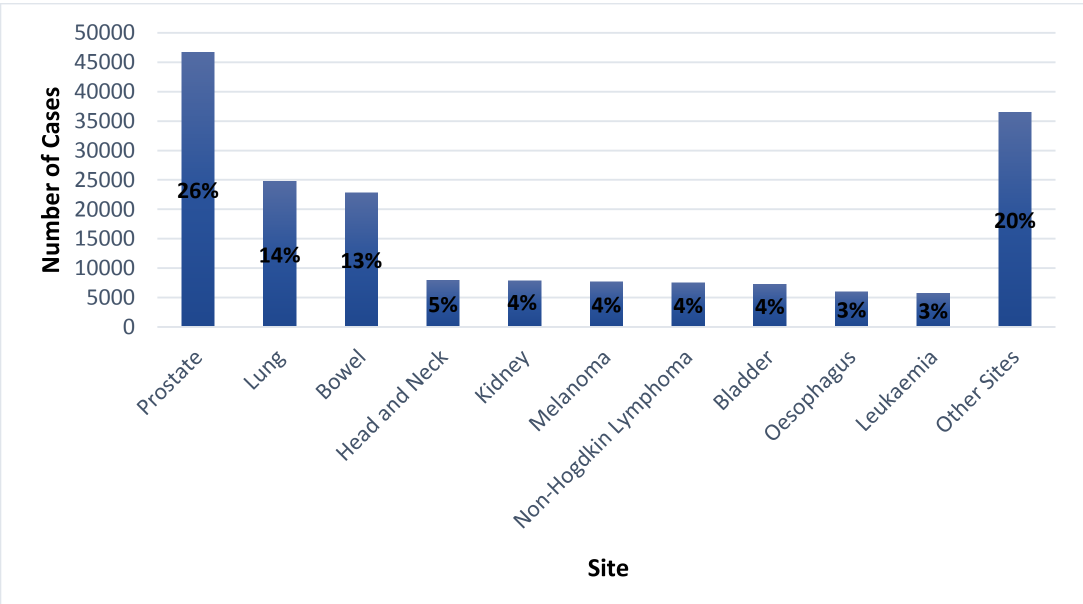


Figure 13.2: Ten most common cancers in males 2014 (data from Cancer Research UK, 2017).

Recent research into the causes of cancer today have concluded that 45% of cancers in males and 40% in females are preventable, and that changes in lifestyle and intervention on environmental factors are the best options for dealing with the disease, together with earlier detection and more effective treatment (Vineis and Wild 2014: 555; Danaei *et al.* 2005: 1784). The major contributors to the causes of cancer include tobacco use, which if greatly reduced, could represent the greatest number of deaths avoided from the disease, and an increase in the consumption of fresh fruit and vegetables, more physical activity, and less alcohol consumed (Vineis and Wild 2014: 552). Indeed, up to date research shows that alcohol consumption can damage DNA and mutate stem cells, causing malignancy (Garaycoechea *et al.* 2018: 1). Other factors which contribute to the risk of cancer include: occupational carcinogens (e.g. asbestos, benzene); infectious agents such as *helicobacter pylori,* hepatitis B and C, and human papillomaviruses; environmental factors, such as air pollution, arsenic, and radon; genetic inheritance; and sunlight (Vineis and Wild 2014: 553-4).

Cancer however, is not a modern disease. In a review of neoplastic disease in the palaeopathological literature, Brothwell (2008) cites examples of individuals with evidence of the disease from prehistory to the medieval period, with only scant data from the British Neolithic. In each Neolithic case, the tumours are considered to have been benign: 1.05% (32/3033) of early British individuals displayed osteomas (but only two from the Neolithic period); a humerus from West Kennet revealed a chondroblastoma upon x-ray examination; and a tibia exhibited an osteochondroma (Brothwell 2008: 271-2).

The reasons why there is so little evidence of neoplastic disease during the Neolithic period may be due to the fragmentary and incomplete nature of the available assemblages. However, Waldron (1996) found that the cases of neoplastic disease found in human skeletal material from the 18th and 19th centuries (from the crypt at Christ Church, Spitalfields), was in the order of magnitude expected, based on modern cases. Furthermore, diagnosing neoplastic disease from dry skeletal collections can be difficult, due to taphonomic factors, curation, completeness, and the fact that some neoplastic diseases are not visible to the naked eye. Rothschild and Rothschild (1995: 358) examined the skeletons of 128 diagnosed cancer patients, but were only successful in recognising the disease macroscopically in eleven cases but recorded three times that many through analysing radiographs. The conclusion from the paper was, when analysing archaeological specimens for signs of neoplastic disease, radiographs should always be used to confirm the diagnosis, which unfortunately is unrealistic, given the logistical difficulties.

13.2: Benign Tumours

Benign bone tumours may exist in several types of tissue – bone, cartilage, or from the soft tissues surrounding the bone, and are summarized in Table 13. 2 (Waldron 2009: 170).

Table 13.2: The most common sites involved with benign bone tumours (Waldron 2009: 171, table 9.2).

Tumour	Sites Most Commonly Affected
Tumours Arising From Bone	
Osteoma	Skull, frontal sinus, mandible, maxilla, EAM
Enostosis	Pelvis, proximal femur, ribs, humerus, tibia
Osteoid osteoma	Femur, tibia, foot, hand, humerus
Osteoblastoma	Vertebrae, femur, mandible, maxilla, tibia, foot
Tumours Arising From Cartilage	
Chondroma	Hand, femur, humerus, foot
Enchondroma	Hand, femur, humerus, foot
Periosteal Chondroma	Humerus, femur, hand, tibia, foot
Chondroblastoma	Femur, humerus, tibia, foot
Osteochondroma	Femur, humerus, tibia, foot, hand, pelvis
Tumours Arising From Other Tissues	
Haemangioma	Vertebrae, skull, ribs, mandible, maxilla, foot
Non- Ossifying Fibromas	Femur, tibia, fibula, humerus
Bone Cysts	
Simple	Humerus, femur, tibia, fibula
Aneurysmal	Tibia, femur, vertebrae, humerus, pelvis, foot, fibula, hand

13.2.1: Tumours Arising From Bone

Osteoma

Osteomas, sometimes referred to as button or ivory osteomas, are one of the most common benign tumours found in archaeological assemblages, and are in fact, found in 1% of all modern autopsies (Capasso 2005: 8). These tumours are composed of both woven and compact bone, and arise from the cortex of the bone. They are most commonly found on the skull and in the sinuses, and depending on location can cause headaches, sinusitis, and other symptoms linked to the obstruction of the paranasal spaces (Motamedi and Seeger 2011: 1115). Furthermore, osteomas which have developed in the paranasal spaces, can invade the orbital and intracranial spaces, occasionally causing exophthalmos (a bulging of the eye anteriorly out of the orbit), double vision, or pressure on the optic nerve, resulting in loss of vision (Greenspan 1993: 485). Button osteomas are slow growing tumours, circular and shiny in appearance, most commonly found on the frontal and parietal bones of the skull, and usually only measuring no more than 2cm in diameter (Ortner 2003: 506). This type of tumour is more common in men than women and reaches a peak of frequency in the fourth and fifth decades (Aufderheide and Rodríguez-Martin 2011: 375).

In the current study, five individuals exhibited a button osteoma, giving a CPR of 1.6% (5/305). Four of the individuals are male, and one a probable male (Table 13.3). Four of the tumours were located on the frontal bone, giving a TPR of 1.7% (3/174 for the left frontal) and 0.6% (for the right frontal, 1/171). However, when the figure is adjusted for sex the TPR is 3.6% (2/55) for the left frontal, and 1.8% (1/55) for the right. The other individual had a button osteoma located on the right parietal, giving a TPR of 2.1% for that element (1/47).

Table 13.3: All individuals in the study exhibiting a button osteoma.

Site	Sex	Age	Location of osteoma	Side	Size mm (ML x SI)
Belas Knap # AI	M?	45	Frontal	Left	15x10
Belas Knap # CIV	M	48-56	Frontal	Left	6x5
Hetty Pegler's Tump (Uley) # 78/1965	M	33-45	Frontal	Right	17x15
Lanhill EU 1.5.109	M	25-35	Parietal	Right	7x5
Randwick # A3081b	M	?	Frontal	Left	15x15

The five examples of button osteoma all conform to the aforementioned description: none of the tumours are larger than 2cm in diameter, the largest example is from Randwick long barrow and is circular in shape. The smallest tumour is from Belas Knap long barrow (# CIV), and is roughly circular in shape. All of the button osteomas are compact, shiny circular nodules on the ectocranial surface of the cranium (Figure 13.3).

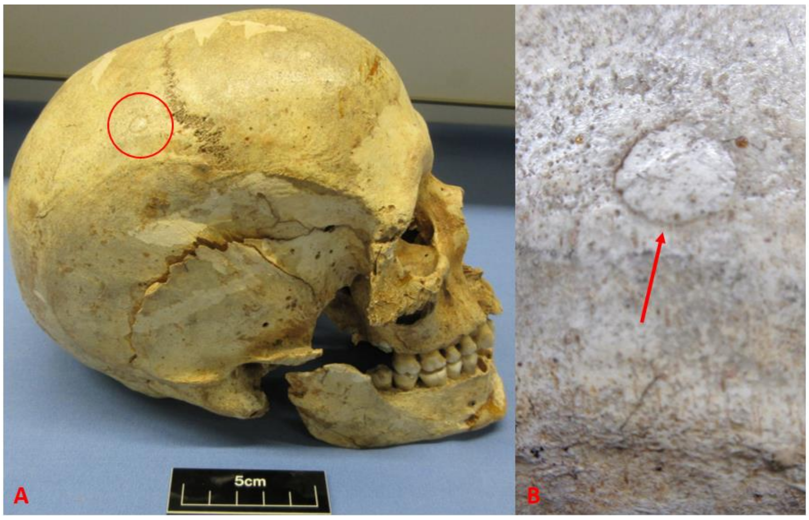


Figure 13.3: A - Button osteoma on right parietal of male adult from Lanhill long barrow (EU1.5.109). B- Detail.

13.2.2: Tumours Arising From Cartilage

Chondroblastoma

Chondroblastoma is a rare benign cartilaginous tumour that arises from the epiphyses of the long bones, in particular, the femur, humerus and tibia, and occurs most frequently during the second and third decade of life, although Turcotte and colleagues (1993; 947) report a 13% incidence after the age of 40 years. Males are more affected than females and the tumour presents in the form of gradually increasing pain to the affected area, tenderness, and a limited degree of movement in the adjacent joint (Suneja *et al*. 2005: 974). Identification of this tumour, even in dry bone, is made easier by the fact that a chondroblastoma is unique in that it only arises and often is confined only to the epiphysis (Ortner 2003: 509). The tumours are fairly small in diameter, measuring between 1cm and 5cm, confined to a small area, producing a destructive lesion with lytic foci (Aufderheide and Rodríguez-Martin 2011: 380). In modern populations, the tumour may be easily treated by curettage, either on its own, or in conjunction with packing of the affected area, but incomplete curettage may lead to a reoccurrence of the condition and rarely to allow the tumour to metastasize (Suneja *et al*. 2005: 977).

One individual in the current study exhibited a possible case of chondroblastoma to the proximal end of the left humerus, giving a CPR of 0.3% (1/305) and a TPR of 2% (1/51) for the left proximal humerus. The probable male from Hazleton North long barrow (Skeleton # 2) is a mature adult, aged between 33 and 60 years and exhibits a deep lesion on the anterior surface, in the area of the anatomical neck which measures 11mm supero-inferiorly and a maximum of 8mm medio-laterally (Figure 13.4). The lesion has a clearly defined outline and exposes the trabeculae beneath. There is a further lesion measuring 4mm supero-inferiorly by 4mm medio-laterally adjacent to the humeral head. The presence of adjacent tumours could suggest that the lack of surgical intervention in the form of curettage has allowed a reoccurrence of the condition, or perhaps indicating that the chondroblastoma had metastasized, although there does not appear to be any further lesions on the rest of the skeleton.

A differential diagnosis could include simple cysts or possible osteomyelitis, where the lesions represent cloacae, or a giant cell tumour, although the lack of any bulbous swelling in the affected area probably makes this unlikely. Alternatively, the lesions may be evidence of some sort of erosive joint disease. Rheumatoid arthritis is the condition most likely to produce lesions in this joint, and the disease is usually symmetrical, but unfortunately the shoulder joint is missing on the opposite side. However, most of the manual and pedal phalanges are present and show no sign of the disease, so a diagnosis of rheumatoid arthritis is perhaps not feasible. However, a differential diagnosis of tuberculosis is also possible.

Figure 13.4: A – Left humerus from an adult male from Hazleton North long barrow (Skeleton #2) exhibiting possible chondroblastomas adjacent to the humeral head. B – Detail.

13.3: Malignant Tumours

13.3.1 Primary Malignant Tumours of Bone

Like benign bone tumours, malignant tumours can also arise in the tissues of bone, cartilage, and the soft tissues, as well as in the blood and lymphatic system (Waldron 2009: 178) (Table 13.4).

Table 13.4: Malignant primary tumours of bone (Waldron 2009: 179; Chowdhry *et al*., 2009; Sumathi *et al*., 2012).

Tumour	Sites Most Affected	Age at Presentation	Sex Preference
Osteosarcoma	Femur, tibia, humerus, cranium, spine, pelvis	10 -25; 40+	M > F
Chondrosarcoma	Pelvis, femur, humerus, tibia, ribs, scapula	50 -70	M > F
Ewing's Sarcoma	Femur, pelvis, tibia, humerus, fibula, ribs	<40	M ≥ F
Fibrosarcoma	Femur, tibia, humerus, pelvis, mandible, maxilla	30 - 50	M = F
Angiosarcoma	Tibia, femur, humerus, vertebrae, pelvis, foot, ribs	30 - 50	M > F
Lymphoma – Non Hodgkin's	Femur, tibia, fibula, spine, pelvis	All	M > F
Lymphoma - Hodgkins	Spine, pelvis, ribs, femur, sternum	All	M > F
Leukaemia - Acute	Any	All	M > F
Leukaemia - Chronic	Femur, humerus	50+	M > F
Myelomatosis	Skull, pelvis, ribs	60+	M > F

Malignant bone tumours can be primary or secondary, the latter more common than the former (Waldron 2009: 177). Primary tumours of bone account for only about 0.2% of all neoplasms diagnosed in the UK and America in adults, which equates to 550 new cases each year, the most common tumours being: chondrosarcoma (33%); osteosarcoma (32%); and Ewing's sarcoma (15%) (Freeman *et al*. 2018: 27). Children and adolescents however, exhibit higher rates of incidence for primary tumours of bone, currently 4% and 7% respectively (Van Driel and Van Leeuwen 2014: 159). Patients typically present with non-specific dull pain of the affected joint, which tends to be more painful at night but does not initially affect movement: in the later stages, swelling and restriction of movement of the joint, and increasing pain may be evident (Sumathi *et al.* 2012: 72).

Osteosarcoma is the most common form of primary bone tumour, and in 75% of cases, affects those aged between ten and 25 years of age, with males being more affected than females – a second peak of incidence is in patients aged over 40 years (McDuff and Reid 2009: 55). The tumour mainly occurs in the metaphyseal area of the long bones and less commonly in the cranium, spine and pelvis (Chowdhry *et al.* 2009: 82). Osteosarcoma arises within the medullary cavity, spreading outwards to the cortical bone, where the periosteum may be lifted and a 'Codman's triangle' of new bone may develop or more dramatically, a 'sunburst' of speculated new bone which lies perpendicular to the affected area (Ortner 2003: 525; McDuff and Reid 2009: 56). The majority of osteosarcomas are aggressive, often progressing to secondary tumours, with a high prevalence in the lungs (Van Driel and Van Leeuwen 2014: 159).

Ewing's sarcoma is a tumour of childhood and adolescence, rarely affecting patients older than 40 years of age, males having a slightly greater incidence than females (Chowdhry *et al.* 2009: 84). Tumours may arise in the soft tissues without involvement of bones, but where osseous tissue is involved, the growths develop in the diaphysis or metaphyseal-diaphyseal areas of the long bones, pelvis and ribs, and rarely in the cranium, spine, scapula, and the bones of the hands and feet (Sumathi *et al.* 2012: 77). Ewing's sarcoma arises within the medullary cavity, penetrating the cortex and periosteum to form a large tissue mass, giving a distinctive moth-eaten appearance or an overlapping 'onion skin' periosteal reaction on radiographs (McDuff and Reid 2009: 57). This tumour is an aggressive form and unfortunately often develops metastases (Van Driel and Van Leeuwen 2014: 160).

13.3.2: Metastatic Bone Tumours

Metastases arise following the spread of cancerous cells from a primary site to organs (including bone) in other areas of the body by a process called angiogenesis: a primary tumour requires a series of new vessels to provide nutrients and oxygen to the site, thereby also providing an exit route for cancerous cells to enter directly into the bloodstream, a process called intravasation (Chambers *et al*. 2002: 563). Following systemic dissemination, the circulating tumour cells (CTC) extravasate into the new site, a process which is determined by blood flow and molecular signalling: CTC from lung tumours have a widespread distribution throughout the body due to venous drainage from the pulmonary vein, which then enters the circulatory system via the heart – conversely, CTC from the breast or prostate tend to accumulate in the thoracic and lumbar regions of the spine respectively, as these areas are adjacent to the affected initial sites (Gdowski *et al*. 2017: 3).

Development of metastatic tumours is dependent on an imbalance of the normally well-regulated system of osteoblastic and osteoclastic formation and resorption, leading to the formation of lesions that are either osteolytic, osteoblastic, or a combination of both (Freeman *et al*. 2015: 35). Osteolytic lesions are usually a feature of metastases from lung, thyroid, kidney, and gastrointestinal primary tumours; osteoblastic lesions are commonly exhibited in metastases from prostate cancer; and metastatic tumours from breast cancer can be a mixture of both (Aufderheide and Rodríguez-Martin 2011: 388).

After the lung and liver, the skeleton is the most common site for metastatic tumours, with the bones rich in red marrow having the most involvement, such as the vertebrae, 70% of which occur in the thoracic region, the proximal femur, ribs, sternum, pelvis and skull (Freeman *et al*. 2015: 34). Any primary tumour can develop secondary tumours, but those of the breast, prostate and lung are the most common (Mundy 2002: 584). In fact, the incidence of metastatic bone tumours in some cancers is very high: up to 70% of patients diagnosed with breast cancer (predominantly females), will develop metastases; 70% of individuals with prostate cancer (males) will develop metastases; those with thyroid cancer 40%; renal, 35%; bronchus, 35%; and rectal, 10% (Freeman *et al*. 2015: 34). Furthermore, childhood cancers may also metastasise, including leukaemia and neuroblastoma, Ewing's sarcoma, Langerhans' cell histiocytosis, osteosarcoma, and non-Hodgkin's lymphoma (Brothwell 2008: 270; Dalrup-Link *et al*. 2001: 231).

Unfortunately, the prognosis for patients with metastatic cancer is very poor, despite improved treatments and survival outcomes within the last 50 years (Gdowski *et al.* 2017: 1). Not only faced with low survivability, patients endure a suite of symptoms and complications with the disease: pathological fracture; bone pain; hypercalcemia of malignancy; nerve root compression; impaired mobility; surgery to bone; radiation to bone; spinal cord compression; infiltration of bone marrow; and general reduction in quality of life (Vassiliou *et al*. 2009: 80).

In the current study, one individual is considered to exhibit evidence of skeletal lesions that may be indicative of neoplastic disease of unknown etiology. The individual (# 1950: 281), a child of unknown age (based on the fragile nature of the cranial fragments), was excavated from Avenis (Smart's Farm, Bisley) long barrow, and is represented by only four fragments of cranium. However, within the assemblage there are also some elements that may also belong to this child: a fused neural arch of a thoracic vertebrae, giving an age of two to five years; and a fused thoracic vertebrae, giving an age of at least five years.

The cranial fragments consist of three pieces of parietal or frontal bone and one fragment of the occipital, none of them exceeding 60mm on the longest axis. All of the fragments have endocranial lesions, ranging from 2mm in diameter, up to 7mm in diameter (Figure 13.5). The lesions are irregular in shape, expose the diploïc layer and have an internal bevelled edge. There does not appear to be any accompanying periosteal reaction.

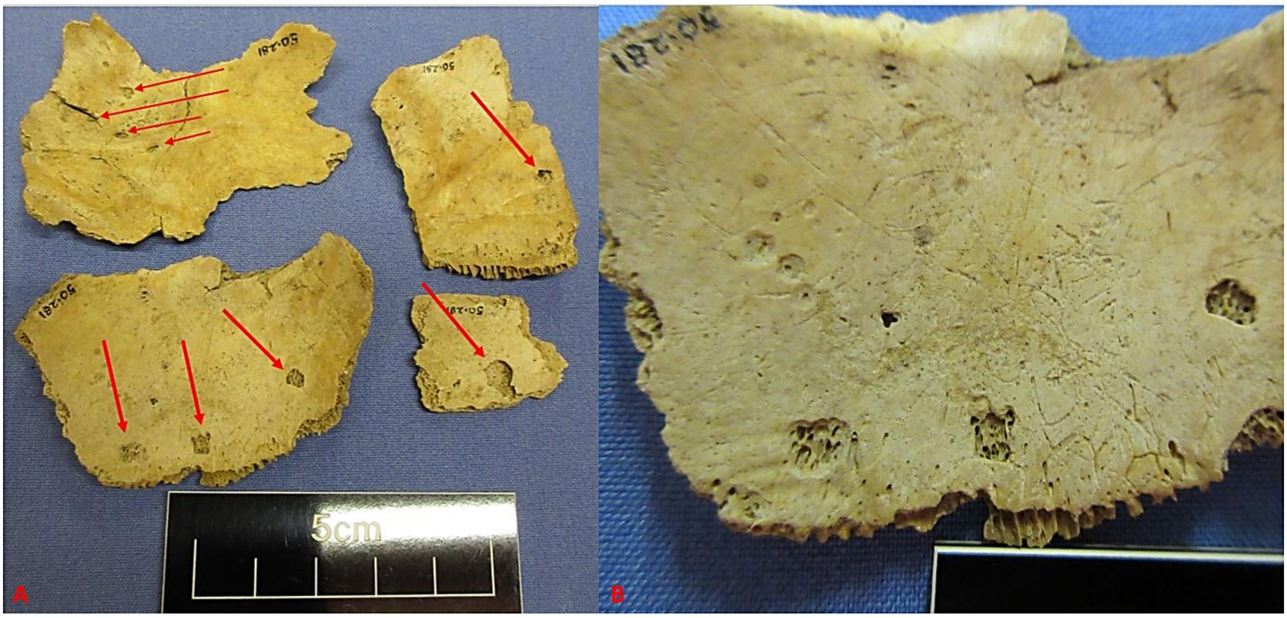


Figure 13.5: A – Cranial fragments from a child from Avenis (Smart's Farm, Bisley) long barrow (# 1950: 281) (occipital top left, rest parietal/frontal), with arrows indicating endocranial lesions. B – Detail of fragment (bottom left in A).

Two of the parietal or frontal fragments also exhibit lytic lesions on the ectocranial surface which expose the diploïc layer beneath, and which are roughly circular in shape, measuring 7mm in diameter, and have an inner bevelled edge. In addition, both of the fragments also feature a discrete area of porosity (Figure 13.6).

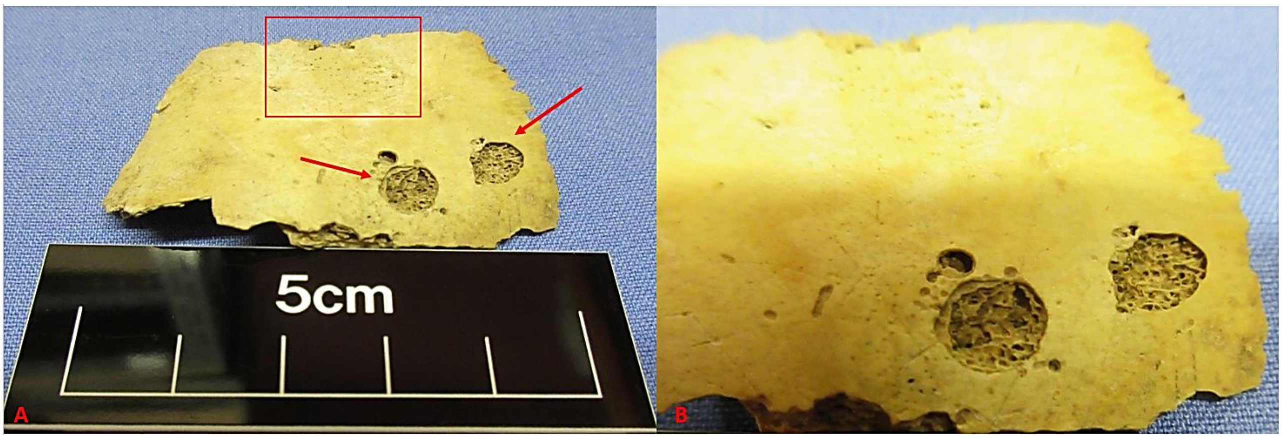


Figure 13.6: A – one of the cranial fragments from a child from Avenis (Smart's Farm, Bisley) long barrow (# 1950: 281) with lesions on the ectocranial surface (arrowed) and an adjacent area of porosity (red rectangle). B - Detail of the lesions.

A differential diagnosis of the disease from which this child was suffering is very difficult to ascertain, given the extremely small amount of material available to examine. However, the lytic lesions on the endocranial and ectocranial surfaces of the cranial fragments are quite distinct and are consistent with the morphology of lesions in metastatic cancer (Amaral *et al*. 2003: 532). It is impossible to state from which type of primary tumour that the cancer has spread given the lack of post cranial bones, but some suggestions could be Ewing's sarcoma, osteosarcoma, neuroblastoma, or leukaemia (Brothwell 2008: 276). Another condition that needs to be considered is Langerhans cell histiocytosis, which is a condition involving a proliferation of pathologic, neoplastic cells, causing 'punched out' lytic lesions with no periosteal reaction. Additionally, the edges of the lesions in the skull have a bevelled appearance due to the asymmetric destruction of the ectocranial and endocranial surfaces of the skull (Morón *et al.* 2004: 1669). In either case, the child died prematurely and was probably sick for a period before death.

13.4: Summary

This chapter has outlined six cases of benign neoplastic disease, and one possible case of malignant cancer for the Neolithic period (Table 13. 5), representing 2.3% of the assemblages (7/305).

Table 13.5: Summary of individuals in this study with neoplastic disease.

Site	Tumour	Sex	Age
Belas Knap # AI	Benign Button Osteoma	M?	45
Belas Knap # CIV	Benign Button Osteoma	M	48-56
Hetty Pegler's Tump (Uley) # 78/1965	Benign Button Osteoma	M	33-45
Lanhill # EU.1.5.109	Benign Button Osteoma	M	25-35
Randwick # A3081b	Benign Button Osteoma	M	?
Hazleton North Skeleton # 2	Benign Chondroblastoma	M?	33-60
Avenis (Smart's Farm, Bisley) #1950: 281	Malignant Metastatic Cancer	?	child

Modern research notes a strong bias of more males affected than females in neoplastic disease. The current study shows that in fact, no females were found to have been affected by the disease (although the sex of the child with possible malignant Metastatic cancer is unknown). Previous studies of the Neolithic period have noted two cases of benign button osteoma, but this study has found five cases, four of which were located on the frontal bone, giving a TPR of 1.7%, which is a higher prevalence rate than that given for modern cases (1% in modern autopsies). Furthermore, when the figure is adjusted for sex, the TPR rises to 3.6% (2/55) for the left frontal, and 1.8% for the right (1/55).

One possible case of a benign chondroblastoma of the humerus has added to the palaeopathological record for this period. None of these conditions would have adversely affected these individuals, only causing mild symptoms. However, the one possible case of malignant metastatic cancer in a young child is the first case to be reported for this period, making it an important discovery. In an age lacking any form of pain relief, the child would have suffered bone pain from the destructive lesions, and probably headaches, resulting in a premature death (Vassiliou *et al.* 2009: 81-83).

Chapter 14: Discussion

14.1: Introduction

Until recently, the excavation and study of human remains was not deemed to be of primary importance in the archaeological world, the main focus being upon the collection and display of artefacts, or consideration of how structures were built (Gowland and Knüsel 2006: ix). Little thought was given to the actual individuals who constructed the monuments and buildings, and who skilfully created the sought-after artefacts so coveted by excavators. Fortunately, this situation is changing and this offers a significant opportunity to apply techniques to skeletal collections and to interrogate interpretations of the past against scientific evidence. The host of information that can be gleaned from the study of human remains allows scholars to recreate past populations on a scale that was not previously possible. Osteological analysis of bone can reveal the sex, age, health and sometimes the status of individuals. Moreover, examination of bone at a chemical level can reveal the diet and movements of people in the past. What scant knowledge there is of the people who inhabited Britain in the Neolithic is based on surprisingly few published osteological reports, the most comprehensive work coming from recent excavations, and a review and re-analysis of the Cotswold Severn tombs by Smith and Brickley (2009).

In order to address a substantial knowledge gap, the current study provides an osteological analysis of in excess of 36,000 whole and fragmented human bones held in collections of human remains excavated between 1700 and 1990 from Neolithic tombs from the south of Britain. These people would have been at the forefront of the transition between the hunter-gathering way of life, to a more settled existence with the introduction of domesticated animals and cereals, a change that would have a dramatic effect on their everyday lives and health. In consequence, there is a real need to examine the collections which have either never been analysed by an osteologist, or have been examined in the past, but without the benefit of modern techniques.

The main research objectives were as follows:

- Obtain demographic data (age, sex, mortality analysis) from each tomb to begin to reconstruct bioarchaeological profiles.

- Record details of paleopathology.
- Assess the health of the population by recording stature and any dietary deficiencies that affects the skeleton.

The nature of burial rites in the Neolithic period dominantly features successive burial in a tomb necessitating the movement of previous burials. This has given rise to assemblages of human remains that are disarticulated, commingled and fragmented, or in the words of Beckett and Robb (2006: 57), “jumbled and scrappy”. Additionally, the casual way in which some of these monuments have been excavated in the past, has led to skeletal collections that are incomplete. This has been due to the unfamiliarity of some elements such as the small bones of the hands and feet, leading to their non-retrieval, or deliberate selection of the most important bones to the excavator, such as Thurnam and his collection of only crania and mandibles from burial contexts (Smith and Brickley 2009: 27).

As such, incomplete, fragmented, commingled and disarticulated assemblages could seem by some researchers to be a great deal of hard work to analyse, for little reward. What, in fact, would be the point in wasting time on these jumbled and scrappy collections, and what can fragmented bones tell us about past populations anyway? Smith and Brickley (2009: 147) acknowledge the difficulties associated with any meaningful diagnosis in disarticulated assemblages, but strongly recommend the re-analysis of collections of human remains from older excavations to assess whether evidence of disease in the past has been missed. The current study provides that.

The methodology adopted was to re-analyse every fragment of bone from as many Neolithic monuments as possible in the time allowed, with the following fundamental research questions in mind:

- Does the re-examination of human skeletal material from the Neolithic period provide insights into burial rites and either confirm current knowledge, or contradict it?
- Do the demographic profiles of those interred within the tombs add insights into who was selected for specific funerary rituals?

- Does examination of the bones allow inferences to be made about the health and diet of the population?
- Can the patterns of traumatic injuries to bone add to the growing corpus of knowledge on an increasing propensity for violence in the Neolithic period?

Importantly, what a complete re-analysis and appraisal of the human remains from this significant period in prehistory may reveal are insights into Neolithic belief systems. By studying the burials, it may be possible to discern any selection bias and the possible reasons for this.

In order to try and put the current study into context, the results of this fresh analysis were compared to the most up-to-date and in-depth study available of Neolithic human skeletal material from Scotland, a re-evaluation of the bones from some Orcadian tombs by Lawrence (2012). Additionally, those assemblages deliberately not re-examined as part of this study, due to the recent re-analysis by other researchers, were also used for comparative purposes: Ascott-under-Wychwood (Galer, 2007); Adlestrop, Notgrove, Sales Lot, and Burn Ground (Smith and Brickley, 2009). Furthermore, the re-examination of the human remains from Parc le Breos (Whittle and Wysocki, 1998) were consulted.

14.2: Burial Practices at Sites

Does the re-examination of human skeletal material from the Neolithic period provide new insights into burial rites and either confirm current knowledge, or contradict it?

The burial record for the Neolithic period is dominated by collective burials, either interred as whole corpses, or as an assemblage of disarticulated bones (Pollard 1997: 50). Primary burials, which can be recognised in an assemblage by the presence of a fully articulated skeleton arranged in anatomical order, are fairly rare within communal tombs, but have been interpreted as the last interment, as the corpse has been allowed to decompose *in situ* without further disturbance, such as Skeleton 1 from Hazleton North long barrow (Saville *et al*. 1990: 103). Secondary burials involve the manipulation of skeletal elements within the tomb, and are evident in three forms: re-arrangement of bones following decomposition; removal of selected bones, which are then placed in other contexts (such as caves); and more rarely, excarnation (Beckett and Robb 2006: 57). The latter rite has been discovered at some causewayed enclosures, but has only been recognised recently at three long barrows: Adlestrop (Smith 2006); Bowl's Barrow (Smith and Brickley 2009), and Parc Le Breos long barrow (Whittle and Wysocki 1998). The last form of burial rite practiced in the Neolithic period is cremation, evidence of which has been excavated from causewayed enclosures, ring ditches, henges, and some long barrows, such as Chestnuts (Barfield, 1961), West Kennet (Piggott, 1962) and Hazleton North (Saville *et al*.,1990).

Forty-one of the sites in the current study had individuals interred within the tomb. Although not technically buried, these are considered inhumations. Only one site, Chestnuts in Kent, was comprised entirely of cremated human material, representing a minimum of seven individuals (one adult male and four unsexed adults, plus two children). The assemblage consisted of 4264 fragments of bone and weighed 3980.39g. Analysis of the cremated bones revealed that temperatures of more than 940^{o}C were reached within the pyres, as the majority of the bones were white in colour. In addition, there was evidence of thumbnail fissuring, transverse fissuring, longitudinal fissuring, patina, and warping on many of the bones.

There was a duality of burial rites of both cremation and inhumation at seven sites (Table 5.5), making approximately 17% of the total assemblage (7/42). It is apparent that the weight of the cremation deposit at these sites is very low and that the heaviest deposit of 187g from Hazleton North long barrow does not constitute the cremated body weight of an adult, which at Spong Hill, was an average of 812.4g (McKinley 1994a: 11). Furthermore, the deposit from Hazleton North long barrow represents at least three individuals – an adult, an infant and a child. Therefore, are the cremations of these individuals just a token deposit, placed in the tomb and the rest of the remains scattered elsewhere? This is certainly a suggestion that is considered plausible by Smith and Brickley (2009: 59), who also find an idea put forward by Henshall and Ritchie (2001) equally compelling. These authors suggest that cremation burials, like unburnt material, were sometimes only deposited within a tomb for a short while, before being removed and disposed of elsewhere, perhaps leaving behind residual fragments (Henshall and Ritchie 2001: 71).

This explanation would be conceivable if the fragmented cremated material that has been excavated from monuments consisted of very small fragments. However, whilst all of the cremated material from the sites contained some very small pieces of bone, some measuring under 3mm, four of the sites had fragments that were much larger. The largest fragment excavated from Hazleton North long barrow measured a maximum of 45.2mm, and a fragment of long bone found in Fromefield long barrow measured 74.6mm. The largest fragment of cremated material from Luckington long barrow was 46mm, with the biggest fragment from Broadsands long barrow measuring 50mm, therefore it would seem implausible that these fragments would be overlooked. Whilst the majority of the cremated material excavated from the north entrance of Hazleton North long barrow was indeed very small and measured 5mm or less (84%, 1172/1376), the remaining fragments measured in excess of 10mm and exhibited the range of vivid colours found in cremation deposits. Furthermore, the fact that the cremation deposit was found in the entrance of the tomb, suggests that it would be relatively easy to notice, and was not hidden away in the back of a dark chamber. It would seem perhaps more likely that the cremated fragments were deposited deliberately, perhaps following selective collection from the pyre, as a representation of the deceased individuals, whilst disposing of the majority of the cremation deposits elsewhere (McKinley 1989: 71).

There is no evidence for cremation at the Orcadian sites. Indeed, the only evidence of burning is at Isbister on the endocranial surface of one cranium, which has been suggested by Lawrence to have suffered post depositional burning (Lawrence 2012: 485). Galer (2007: 202-205) reports that at least two individuals were cremated and interred within Ascott-under-Wychwood long barrow. Brickley and Smith (2009: 58) note that cremated human bone was amongst the assemblages from Notgrove, Adlestrop, Stoney Littleton and Sales Lot, a fact that had gone unnoticed and unreported by previous experts. The assemblage from Parc Le Breos also contained some cremated human bone, a fact that had not been reported by the excavators of the monument in the nineteenth century (Whittle and Wysocki 1998:150). The present study also found cremated human remains with the bone excavated from Fromefield long barrow, but this had not been mentioned in the original report written by Keepax (1973). The reason why the evidence of this distinctive burial practice has been omitted from so many excavation reports is unclear. It may be due to the fact that in the past, perhaps cremated human bone was not considered to be of importance, or it was simply a case of not being recognised as human. Whatever the reason, it has to be considered that the rite of cremation may have been practiced far more in the Neolithic period than previously reported, and evidence may still be found within assemblages that have to be re-examined by osteologists.

In addition to the rites of cremation and inhumation at Hazleton North long barrow, it is now apparent that excarnation was also practiced at the site. The most complete skeleton that was extensively chewed by canids was Skeleton C, an adult female. Skeleton A, an adult male, also had evidence of scavenging by canids. A child (Skeleton G) aged between two and a half years and four, and another child, Skeleton H, aged between two and three years, also had evidence of scavenging on the bones, in the form of gnawing by canids. Therefore children and adults of both sexes were subject to the rite of excarnation at Hazleton North long barrow.

The lack of postcranial elements at many of the sites studied has unfortunately eliminated the possibly of uncovering more evidence of this nature at other sites. However, the exciting new discovery of the rite of excarnation, through the scavenging of canids at Hazleton North long barrow adds greatly to the archaeological record, and gives insights into the religious beliefs of people in the Neolithic, whilst not relying on the lack of the small bones of the hands and feet to infer this practice in the past. According to most archaeological reports, excarnation was not practiced in the Early Neolithic period, except at Adlestrop long barrow (Smith 2006), Bowl's Barrow (Smith and Brickley 2009) in southern England, and Parc Le Breos long barrow (Whittle and Wysocki 1998) in Wales. However, evidence of this rite has been found at some later causewayed enclosures, such as Etton (Armour-Chelu 1998), Windmill Hill (Brothwell 1999), and Hambledon Hill (McKinley 2008). Contra to the bone report by Chesterman (1983), there is no evidence of excarnation at Isbister, and if this ritual was ever practiced at or near the site, there is no sign of it on the bones (Lawrence 2012: 579).

However, the important discovery of scavenging by canids at Hazleton North long barrow and Bown Hill long barrow during the present study emphasizes the need to re-examine collections of human remains that have previously been analysed. Even though the assemblage from Hazleton North was only excavated just over three decades ago, knowledge gained from experimental archaeology has allowed osteologists to better understand formation processes to interpret funerary behaviour in the past. In consequence, this study augments knowledge on the use of different burial rites within the Neolithic period, and suggests that these practices may have been more widespread than previously thought, and that a re-evaluation of all extant assemblages that have not been examined recently needs to be undertaken.

The extent of fragmentation exhibited in most of the collections of the unburnt bones from the sites, which was commonly noted at the time of excavation, would seem to imply that a degree of manipulation of the assemblage was undertaken during the lifetime of the monuments. Indeed, Colt Hoare describes the discovery of human remains within long barrows, where “skeletons [were found] on the floor of the barrow … lying in a confused and irregular manner “(Colt Hoare 1812: 21). Sorting of the human remains into bundles seems to have been practiced at Hazleton North long barrow, where Skeletons C, F, G, and H were arranged in discrete piles, and were preserved beneath a fallen orthostat (Saville *et al.* 1990: 122). Beside taphonomic processes and tomb collapse, the consequent collection of the human remains has probably caused further breakage, which was certainly the case at Hazleton North long barrow (Saville *et al.* 1990: 81). Furthermore, additional breakage to some elements in the skeletal collections was noted between visits to analyse the assemblages, which demonstrates the fragile nature of the extant bones.

It was not possible to infer the insertion of any further primary burials into the tombs, except for the adult male (Skeleton # 1) from Hazleton North long barrow, which has already been mentioned. Keiller and Piggott (1938: 127), also interpret the last burial to be inserted into the north-west chamber of Lanhill long barrow to be a primary burial (Keiller and Piggott 1938: 127).

It proved to be impossible to discover whether any differential sorting and removal of specific elements was practiced at the analysed sites. This is mainly due to the fact that preferential collection was carried out at most of the sites excavated in the nineteenth century, with the consequence that assemblages were heavily biased with cranial elements. However, the re-analysis of the human remains from Hazleton North long barrow revealed no apparent bias in skeletal elements, with most bones represented.

14.3: Demography

Do the demographic profiles of those interred within the tombs add insights into who was selected for specific funerary rituals?

Research carried out for the current study indicated that there were 480 burials reported from the excavations at the 42 sites examined, but a MNI of 305 individuals only were available for study, representing only 64% of those expected (305/480). The number of individuals interred within the different monuments varied, with a range of one up to the maximum of 42 individuals. However, even if all of the reported burials had been available for analysis, this number of individuals cannot possibly represent the entire buried populations from this period. Brothwell (1972-3: 79) suggested a population of between 10,000 and 40,000 people for the Neolithic period, based mainly on ethnographic data. This raises the question, if only a very small percentage of the community was interred within the monument, where were the remains of the rest of the people deposited?

It has been suggested in the past that causewayed enclosures were a repository for early Neolithic burials (Scarre 2007: 23; Whittle *et al*. 1999: 362), as many human remains have been excavated from these structures, but recent work by Whittle and colleagues (2011: 723) asserts that causewayed enclosures were not contemporary with long barrows, but a later tradition (albeit, only 50 to 275 years later). Therefore, the burials inserted into ditches at these structures were either contemporary with the timespan of the enclosure or perhaps were bones that were specially selected and removed from long barrows at a later date (Whittle *et al*. 1999: 362).

Parker Pearson and colleagues (2006: 236) discuss the possibility that the builders of Stonehenge disposed of their dead in the River Avon, en route to the monument as part of a ceremonial procession from Durrington Walls during the midwinter solstice. If this can be considered a plausible theory in the Late Neolithic period, it may well have been the case in the Early Neolithic too. As Field (2006: 102-106) points out, a considerable number of long barrows are located near, or upstream, from rivers. Could the placement of these monuments close to running water be a convenient alternative method of disposal of the dead for those individuals not interred within the community tomb? If so, it may explain the paucity of Neolithic burials in the archaeological record.

14.3.1 Mortality profiles

Of the sample of Neolithic burials examined by Smith and Brickley (2009) there are far greater numbers of males than females, with an overall figure of 61.9% (65/105) for males (Smith and Brickley 2009: 88). The present study would seem to confirm this trend. The number of males was 63, out of a possible total of 223 adults in this study (28%, 63/223). A further 34 adults were considered to be probably male (15%, 34/223), giving an overall total of 43% (97/223) for male or probably male. The figures for females in the assemblage were 57 (26%, 57/223) and eleven probable females (5%, 11/223), giving an overall total of 31% (68/223). However, a high number of the adults could not be determined for sex, comprising 26% of the total (58/223), which will have an obvious effect on the overall result. Therefore, the percentage of males and probable males in this study is 58.8% (97/165) and 41.2% for female and probable female (68/165). This is an unfortunate result of analysing disarticulated and commingled collections of human material that are highly fragmented, and which, when determined for sex, can skew the results. Even in the larger assemblages, such as those from Hazleton North and West Kennet long barrow, the given numbers of both sexes is not an accurate reflection on the sexual bias within the tomb, depending on the element used for sexual determination. For instance, the number of males at Hazleton North is given as five, with one possible male. However, there are thirteen left tali that easily fall within the range for males, albeit that the range is based on a modern Italian population. However, there is only one left talus that falls within the range for females, so if this element was used for the determination of sex within Hazleton North long barrow, the results would be not only misleading, but skewed.

It was clear from the analysis of the human remains from this site that there was a larger presence of females interred within the monument. This was based on the presence of eight very gracile left scapulae, not only the overall size but with the dimensions of the glenoid fossa (with the caveat that the dimensions are based on modern American data), indicating that the females in the tomb were numbered at least eight. However, in order to determine sex using the same element, the ossa coxae were used, which provide a more accurate determination that in this case was five males and one probable male; three females; and thirteen undetermined adults. It was decided not to document the sex of the sub-adult remains in the collection, as the methods used gave ambiguous results and were therefore considered unreliable (Cunningham *et al*. 2016: 18).

The total number of adults in the collection was 223 out of the total of 305. This category was then subdivided into age categories where possible: young adults accounted for 69 individuals (31%, 69/223); there were 54 middle adults (24%, 54/223); and 23 old adults, comprising 10% of the assemblage. The remaining 35% (77/223) of the adults could not be assessed for age. A surprisingly low number of adolescents were present in the group – only 16 individuals, which only comprises 5% (16/305) of the total. The reason for this is unclear but may be that if individuals survived childhood, they were then less likely to die during their teenage years, as the number of children is significant at the two sites with the highest MNI (Hazleton North and West Kennet long barrow), despite low numbers at all the other sites together. Conversely, the low number of adolescent skeletons at the sites may perhaps infer differential mortuary practices (Roberts 2012: 59). The numbers of children who died below the age of 12 within Hazleton North long barrow and West Kennet long barrow are 17 (Table 14.1) and 16, accounting for 41% (17/41) and 38% (16/42) of the total populations respectively.

Table 14.1: Numbers of each age class at Hazleton North long barrow.

Age Class	# Hazleton North	# West Kennet
Infant (0 – 3 years)	**7**	**9**
Child (3 to 12 years)	**10**	**6 + 1 (unaged child)**
Adolescent (12 – 20 years)	**2**	**1**
Adults	**22**	**25**
Total	**41**	**42**

The reason why children represented within the assemblages overall is very low – lower, in fact, than the figure discussed by Lewis of 30% for child mortality rates in pre-industrialised countries (Lewis 2007: 22), could be due to discrepancies in the survival of bone from children because of the delicate nature of these diminutive elements. Indeed, this was the case in a study by Bello and Andrews (2006). However, at Hazleton North and West Kennet the immature human remains were generally taphonomically similar to those of the adults. Alternatively, under-representation of sub-adult material may be due to the excavator’s unfamiliarity with the bones of children, which may never be recovered, or not sieved, and consequently lost. However, there is the real possibility that the bones of children were not deemed important enough to be kept by the excavator.

The mortality pattern revealed by the re-analysis of the burials from some Orcadian Neolithic tombs by Lawrence (2012) shows a bias in sex in favour of males buried within the tomb in a ratio of approximately 2:1 at Isbister (Lawrence 2012: 223). The number of adults from the site varied depending on the element used. Forty-eight individuals were aged based on dentition: 18 in the 18-25 age category; 5 in the 25-35 group; five aged approximately 35; and 20 individuals were indeterminate for age (Lawrence 2012: 201). However, using crania to determine age, 12 were considered to be in the young adult category, and 39 in the older adult category (Lawrence 2012: 202). The number of adolescents at this site was also very low and comprised of only two individuals, whereas there was a peak in deaths between the ages of four and seven (Lawrence 2012: 202). The reason why this figure is higher in this age group may be due to infection and malnutrition following weaning after the age of four years (Lawrence 2012: 580). Interestingly, 24% (4/17) of the aged children from Hazleton North long barrow also died within this time period, possibly for similar reasons.

The assemblages from Ascott-under-Wychwood long barrow and Parc Le Breos long cairn also consisted of more males than females: eight males and three females at the former site, and eleven males and nine females at the latter (Galer 2007: 218; Whittle and Wysocki 1998: 162). Seventeen of the individuals from Ascott-under-Wychwood (81%, 17/21) were adults: 3 young adults; 4 aged between 26 and 35; 3 aged between 36 and 45, 1 aged 46+ years, and 6 were in the 18+ category (Galer 2007: 218). The presence of adolescents at these two sites was also low - there was only one adolescent present at Ascott-under-Wychwood, aged between 13 and 17 years, and four at Parc Le Breos, but no ages were given. However, there was a similar proportion of infants and young children at the sites – four at Ascott-under-Wychwood long barrow (19%, 4/21) and eight at Parc Le Breos (20%, 8/40).

These data concerning burial practices within the Neolithic period from the present study make it clear that even though the proportion of males to females interred within the monuments is greater overall at 97 males and probable males (58.8%, 97/165) versus 68 females and probable females (41.2%, 68/165), the difference is slightly less marked than in other the studies discussed. What can be ascertained is, that at the nine sites with an MNI over ten (Table 4.1, Chapter 4) both sexes are represented in the burial assemblage (Table 5.7, Chapter 5). Even though in smaller numbers, infants, children and adolescents, representing 27% of the assemblage (82/305) were also afforded the rite of burial. Furthermore, the evidence of excarnation from Hazleton North long barrow, reveals that adults of both sexes and young children also underwent this funerary practice. This demographic pattern is echoed at Adlestrop long barrow, where one male, a female, an unsexed adult, plus three children had skeletal damage consistent with scavenging from canids, prior to burial within the tomb (Smith 2006: 674).

At the seven sites from the current study with both evidence of inhumation and cremation burials, five of the sites (Broadsands, Fromefield, Luckington, Stoney Littleton, and West Kennet) only appeared to have the cremated remains of adults interred within the monument. It was not possible to determine sex from the remains, as the fragments were mostly very small, and no bones from which sex could be estimated survived. However, the cremation deposits from Hazleton North long barrow and Haddenham long barrow contained adult remains and those of a child and infant and an adult and infant respectively. The cremation deposit from Parc Le Breos also contained adult remains and immature material, although the authors could not be definite about whether the latter was human or faunal, due to the diminutive size of the fragments (Whittle and Wysocki 1998: 161).

Therefore, it would seem that both sexes, juveniles and children are represented within the burial assemblage in this current study, and that inclusion within a Neolithic monument was not dependent on sex. This infers that some other critieria for inclusion was likely.

<u>14.4: General Health of the Population</u>

Does examination of the bones allow inferences to be made about the health and diet of the population?

14.4.1: Stature

The estimation of stature in skeletal remains can give insights into the health and nutritional status of individuals in the past, with ultimate adult height dependent on access to adequate nutrition, the extent of exposure to infectious agents and genetic factors (Mays 2010: 136; Larsen 2003: 14). Roberts and Cox (2003: 396) give the average male stature for the Neolithic as 165cm and 157cm for females in a synthesis of excavation reports from sites dating to the period. The present study found that male stature ranged from 158cm to 176cm, with a mean stature of 167cm. Females ranged in stature from 148cm to 163cm, with a mean of 156cm. Due to a lack to whole long bones at Parc Le Breos, only three measurements were obtained to assess stature, and these were all from females, ranging from 143cm to163cm (Whittle and Wysocki 1998: 163). Galer (2007: 217) reports figures that are consistent for stature with those given by Roberts and Cox (2003: 396) for three individuals (two males and one female) but notes that one male was much shorter than the other two, at 159.3cm. However, Lawrence (2012: 499) found a greater disparity in stature between the sexes at Isbister, where the shortest female was reported to be 147cm tall, and the tallest 166cm. The range for the males was from 163cm to 179cm, with an average of 168cm, and an average of 150cm for the females (Lawrence 2012: 299).

According to Roberts and Cox (2003: 396) the average stature increased in the following Bronze Age to 172cm for males and 161cm for females. The reasons for this increase may possibly reflect genetic differences in an increasing population or may be connected to the shift in dietary habits during the preceding Neolithic period, which witnessed a rapid shift from marine sources of protein, to that of terrestrial sources (Richards and Hedges 1999; Schulting and Richards 2002). A diet consisting of domesticated animals (cattle and pigs) and processed cereals is higher in protein than one from marine sources, which was the staple of Mesolithic communities (Richards and Schulting 2006: 452). Indeed, research conducted by Hedges *et al.* (2008) found that the burial assemblage from Hazleton North long barrow had consumed a diet that was very high in meat or animal products, equating to 75% by weight of protein (Hedges *et al*. 2008: 122).

The Neolithic period introduced unprecedented problems for a rising population, in the form of the risk of crop failure and reduced reliance on hunting and gathering of wild resources. In addition, prolonged exposure to domesticated animals and a more sedentary existence would have introduced a new range of infectious agents into the population. However, an increase in dietary protein following the establishment of agriculture, and acquired immunity from infectious diseases would seem to have had a beneficial effect on the health of the population as time progressed (Figure 14.1).

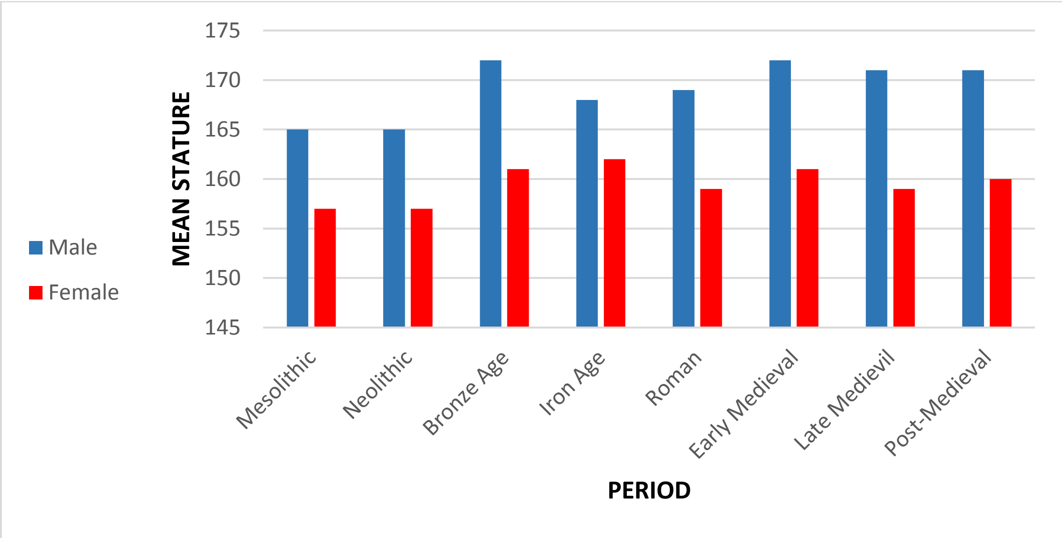


Figure 14.1: Mean stature of males (blue) and females (red) from the Mesolithic period to Post Medieval period (Data source: Roberts and Cox (2003: 396).

14.4.2 Non-Specific Indicators of Physiological Stress

Cribra Orbitalia

Cribra orbitalia is considered to be an indicator of physiological stress and the aetiology of the disease is not straightforward but related to nutritional deficiency and infectious agents, coupled with the health of the pregnant mother and consequent breastfeeding practices (Walker *et al*. 2009: 119). Cribra orbitalia is considered to be more prevalent in children, but where there are signs of the condition in older individuals, it is considered to be a relic of childhood disease (Stuart – Macadam 1985: 393; Walker *et al.* 2009: 111). However, the current study produced 21 individuals who were considered to be suffering from the condition, but only two were juveniles - one from Belas Knap long barrow (# EU.1.5.9) and the other from Norton Bavant long barrow (# EU.1.5.101b), had evidence of the condition, and neither was severe. In fact, the lesions exhibited by these individuals were in the process of healing when death occurred. The remaining 19 individuals were all adults, suggesting that the modest porosity seen in the orbits was from an episode of the disease in childhood.

The CPR for the condition is therefore 7% (21/305) and the TPR is 14.6% (38/261 orbits examined).

Roberts and Cox (2003: 67) report a crude prevalence rate of 13.8% (18/130) and a true prevalence rate of 26.9% (14/52) for cases of cribra orbitalia from three Neolithic sites. The reason why the present study reports a lower CPR than that given by Roberts and Cox may be partly due to the fact that six individuals reported as suffering from cribra orbitalia at Hazleton North long barrow by Rogers (1990: 196) were included in their data, but only two were considered by the present author to have this condition – the other four were likely suffering from scurvy. In this study, males were affected more commonly than females when the CPR's are compared - six males and five probable males (3.6%, 11/305), to six females and two probable females (2.6%, 8/305). However, the data for TPR suggest an almost equal distribution between the sexes, with females having a TPR of 15%, (11/73) and males 14% (12/86). Lawrence (2012: 355) reports nine cases of cribra orbitalia in juveniles, and 15 cases in adults (nine males, four females and two indeterminate), none of them seemingly severe. This evidence, together with that from the present study and the data from Roberts and Cox (2003) and Lawrence (2012) suggests that cribra orbitalia was not particularly prevalent in the Neolithic period. Conversely, the fact that 90% (19/21) of those individuals affected in the current study were adults, suggests that cribra orbitalia may have been a significant problem at this time. The individuals who experienced a period of physiological stress, had low frailty, and were therefore able to survive into adulthood (Wood *et al*. 1992: 350).

Porotic Hyperostosis

As with cribra orbitalia, the etiology of porotic hyperostosis was considered to be iron-deficiency anaemia, but the work of Walker *et al*. (2009) considers that this condition is due to megaloblastic anaemia, which is passed on by nursing mothers with depleted reserves of vitamin B12, caused by lack of animal protein and vitamin-rich plant foods in the diet, together with weaning foods that are deficient in nutrients (Walker *et al*. 2009: 113). The CPR for this condition was 20% (61/305) and affected 61 individuals from 15 sites (36%, 15/42), but only three of the affected were sub-adults, and none were severley affected, as the lesions were in the process of healing at death. When the TPR for sex was calculated using the three most common regions of the cranium affected, it was found that males had a higher prevalence of the condition than females in two regions. On the frontal, males had a prevalence of 12% (8/66) and females had 8.3% (4/48), and on the occipital, males had a rate of 11% (5/45) and females 3% (1/38). However, females had a higher prevalence of porotic hyperostosis on the parietals, which was incidentally, the most commonly affected region on the cranium (63%, 50/79). The rate for females was 16.9% (13/77) and 13.6% for males (13/96).

The re-analysis of the human remains from Isbister revealed that 26% (22/85) of the assemblage suffered from porotic hyperostosis, with the majority of those affected being adults (Lawrence 2012: 355). It is unclear why the majority of those affected were adults. These individuals must have been nutritionally deprived as young children, but obviously survived until adulthood as the lesions were healing at time of death. The lack of evidence of porotic hyperostosis on sub-adult crania at this site simply reflects the fact that there are very low numbers of young children present - only 12 below the age of four years (Lawrence 2012: 227). However, there are larger numbers of children present at West Kennet and Hazleton North long barrow, yet only one exhibited evidence of porotic hyperostosis at the former site. This child, Skeleton EU.1.5.145 from West Kennet, is estimated to have been aged six to seven years and had active lesions on the parietals and frontal at time of death. The affected adult crania from the present study may reflect a short period of nutritional stress due to crop failure and other environmental factors experienced when young that was resolved. Only one individual is considered to have porotic hyperostosis from Parc Le Breos on a small fragment of cranial vault (Whittle and Wysocki 1998: 162), which presumabably could not be assessed for age or sex.

Enamel Hypoplasia

Development of linear enamel hypoplasia in the surfaces of the teeth reflects a period of malnutrition or poor health during the childhood years, when the tooth crowns are developing and which is so severe that enamel deposition is affected or suspended (Langsjoen 2011: 405). The examination of all occluded and loose teeth in the current study revealed a CPR for EH of 10.9%, with 21 adults affected (21/192). Males were more affected when the CPR’s are compared, with 5.5% (9/165) for males, and 4.8% (8/165) for females. The TPR was 2.2%, with 46 of the 2111 teeth affected. Four males and five possible males, eight females and one possible female, plus four indeterminate adults were found to have suffered from EH. When the TPR is adjusted for sex, females had 21 teeth affected, giving a TPR of 5.5% (21/384). Males had only five teeth affected, giving a TPR of 1% (5/585). One child from Luckington long barrow was unlucky enough to have suffered from two life-threatening events at the ages of approximately 4.7 years and 3.6 years.

Roberts and Cox (2003: 67) give a CPR of 2% (5/196) of enamel hypoplasia in their synthesis on Neolithic sites. Lawrence (2012: 342) states that there was a very low prevalence of EH at Isbister, but unfortunately gives no data to support this. Galer (2007: 215) also gives a low figure for EH at 1.4%, affecting only three teeth out of a total of 222. Four permanent canines from one of the chambers at Parc Le Breos were affected by EH, as well as in two unerupted permanent incisor crowns from another part of the tomb (Whittle and Wysocki 1998: 163). Galer (2007: 215) suggests that the low figures for EH at Ascott-under-Wychwood indicates that the individuals in the community did not suffer high levels of stress during early life. However, the individuals who exhibited lesions on the dentition survived the period of stress, and resumed normal enamel formation thereafter. Those of a weaker constitution did not survive long enough to form lesions, and will therefore exhibit an unflawed (for EH) dentition (Wood *et al*. 1992: 355).

There were a number of individuals in the current study who had evidence of EH and who also showed evidence of healing porotic hyperostosis (Table 14.2). Seven individuals out of the 21 recorded with EH (33%, 7/21) also had porotic hyperostosis, perhaps suggesting that in these cases, the EH was related to a severe period of nutritional deprivation. Furthermore, the female from Imber (EU.1.5.78) also exhibited cribra orbitalia. Two out of the seven individuals were female (29%, 2/7), two were males and the remaining three individuals were probable males 71% (5/7). The females had three teeth affected by EH (0.2%, 3/1650 occluded teeth), and the males and probable males had eight (0.5%, 8/1650). Despite representing only a small sample of those analysed in this study (2.3%, 7/305), these data may paradoxically infer that males were more adept at overcoming periods of starvation with greater survival or that females did not survive these episodes and died (Wood *et al*. 1992: 355).

Table 14.2: Individuals with both enamel hypoplasia and porotic hyperostosis.

SITE	SEX	# Teeth Affected (EH)
Giant's Hills EU.1.5.114	Male	1
Imber (Bowl's Barrow) EU.1.5.78	Female	1
Winterbourne Monkton EU.1.5.29	Male?	4
Winterbourne Monkton EU.1.5.39	Male?	1
West Kennet EU.1.5.142	Female	2
West Kennet EU.1.5.150	Male	1
West Kennet Skeleton IX	Male?	1

The evidence of both conditions occurring in seven individuals, and from four different sites, is spread across a wide geographical area – from Lincolnshire (Giant's Hills) to Wiltshire (Winterbourne Monkton, Imber, and West Kennet). This may possibly reflect common cultural practices across southern Britain during the Neolithic period. The evidence from these individuals, albeit a small sample, may perhaps infer that not everyone had equal access to plentiful food resources, and that the burials do not represent a microcosm of an egalitarian society, where there is limited differentiation in social ranking (Renfrew and Bahn 2008: 199). Although far removed from antiquarian notions of chiefdoms (Thurnam 1869: 185), the organisation of manpower required to build such massive monuments would have necessitated the appointment of a leader (Parker Pearson 2008: 35). The inclusion of individuals within the tomb who may have suffered periods of malnutrition, while others did not, may point to all things not being equal, and that perhaps the idea of social equality during the Neolithic is unrealistic.

14.4.3 Nutritional and Dental Health

Scurvy

Scurvy is caused by lack of vitamin C in the diet and is required on a daily basis, as it cannot be stored in the body because it is soluble in water (Waldron 2009: 131). Sources of vitamin C are found in fresh fruit, vegetables, and to a lesser extent, in marine fish, meat and milk (Fain 2005: 124). Evidence of scurvy in human skeletal remains may reflect seasonal availability of fresh fruit and vegetables, and changing subsistence practices. Therefore, the temperate climate and unprecedented changes brought about by the introduction of agriculture during the Neolithic period in Britain may not have been that beneficial to the consumption of a healthy, well-balanced diet. Hunter-gatherers select fresh foodstuffs on a daily basis, typically utilising between 200 and 300 different plant foods, thereby ensuring that they have a well-balanced diet (Cordain 1999: 23). Conversely, the transition to agriculture limited the range of plant foods utilised, reducing the quantity to only between 20 and 50 species, with a greater reliance on cereals and stored goods, which contain little or no vitamin C (Cordain 1999: 23). Additionally, tending animals and crops is more time consuming, leaving less time to gather wild species of plants and fruits, which in Britain, would only be available on a seasonal basis anyway (Brickley and Ives 2008: 52). However, according to Mays (2014: 60) the seasonal fluctuations in availability of fresh fruit and vegetables is not a credible explanation for the presence of scurvy in past populations, and is more likely to be explained by cultural, rather than environmental factors.

To date, there have been no cases of scurvy reported in the published literature for the Neolithic period, except for a possible case from West Tump long barrow, where an infant exhibits porosity and new bone formation on the orbital roof (Smith and Brickley 2009: 120). However, Lawrence's (2012: 350) thesis on the human skeletal material from Isbister reported a high prevalence of scurvy in the population, based on the high frequency of ante-mortem tooth loss and periodontal disease at the site. Isolated palatal pitting in 36 individuals was also considered an indicator of the disease (Lawrence 2012: 359), as was porosity of the ectocranial surface of the sphenoid in 14 adults and four children (Lawrence 2012: 361). Furthermore, two cases of possible scurvy are tentatively suggested by Lawrence, where evidence of haemorrhage was evident in the orbits of a child aged four years, and a neonate of less than three months had woven bone associated with muscle attachment sites on the long bones (Lawrence 2012: 362-364). A tibial fragment with superficial woven bone and the scapula of a juvenile exhibiting porosity and woven bone are also suggested as indicative signs of scurvy (Lawrence 2012: 365). Finally, cortical thickening of six femora and supratrochlear woven bone on several other femora is reported as further evidence of widespread Vitamin C deficiency in this population (Lawrence 2012: 369-370).

The reported extent of scurvy at Isbister is rather surprising. The numbers of individuals affected may perhaps be artificially inflated, due to the criteria used to diagnose the condition. According to Ortner *et al.* (1999; 2001), the porous lesions of scurvy may be exhibited on the ectocranial vault, the orbital roof, the greater wing of the sphenoid, the posterior surface of the maxilla, and on the hard palate. Additionally, lesions may be found on the long bones and on the ribs. Lawrence (2012) describes many of these locations on the skeletal human remains from Isbister as possible cases of scurvy, but it would appear that the porosity does not appear as a suite of indicators in particular individuals but on isolated bones.

Six new cases of scurvy were presented in the current study from three sites, giving a CPR of 2% (6/305). All of the cases involved infants or children no older than eight years of age, who all exhibited porosity and new bone formation on the cranium or mandible, and in the case of the infant from Fromefield (Skeleton # 1), also had evidence of porosity on all of the extant long bones. In addition, this individual also had endocranial lesions on the parietal bone. The fact that three of the individuals with evidence of scurvy were infants (from Fromefield long barrow, Hazleton North long barrow, and Belas Knap long barrow) indicates that there was insufficient vitamin C in the breastmilk, and that the individuals responsible for feeding the infants were themselves suffering from scurvy. The nine month old baby from Hazleton North long barrow may have had a limited vitamin C intake from the mother while *in utero*. However, if the infant was then breastfed by another individual who was suffering from scurvy, or indeed, if the mother did not receive sufficient levels of vitamin C following the birth, the deficiency of the nutrient would take a few months for the recognisable signs of the disease to appear in the baby. The remaining two older children, aged between five and six years, and about eight years old at death from Hazleton North long barrow, would have long past the weaning stage and would have needed a regular intake of vitamin C to avoid scurvy.

It is interesting to note that four of the six individuals (67%) with scurvy from the current study all came from the same site, Hazleton North long barrow. Furthermore, the mother, or the individual responsible for feeding the infant, would also have been suffering from vitamin deficiency, indicating that five individuals out of the forty-one present at the site (12%) had a vitamin C deficient diet, which would have been a significant problem in the past.

It is rather surprising that evidence of scurvy should be so prevalent at Hazleton North long barrow. Some of the teeth from the burials from this site were recently submitted for strontium and oxygen isotope testing to evaluate the residential patterns of the community (Neil *et al*. 2016). The results showed that the majority of those tested did not lead a sedentary life at Hazleton North, but routinely moved between two disparate regions of the country, which were at least 40km apart (Neil *et al*. 2016: 9). The authors contend that the closest proximal location that fits the strontium isotope results is either to the west or south-west, in areas such as [west] Gloucestershire, Herefordshire or Worcestershire (Neil *et al*. 2016: 9). One of the individuals whose teeth were submitted for analysis is a child aged approximately eight years (# 12527), and was considered by the present author to be suffering from scurvy. This was exhibited in porous new bone formation in the orbits, porosity on the superior portion of the squamous temporal and the greater wing of the sphenoid (Chapter 6, Figures 6.3 and 6.4). So it seems rather surprising that this child (and others who were not tested but presumably conform to the same pattern of mobility) did not receive an adequate supply of vitamin C, considering the range in area that the community covered, and the possible difference in vegetation in both areas.

Evidence of plant foods rich in vitamin C have been excavated from Neolithic sites, including crab apple (*Malus sylvestris*), raspberry or blackberry (*Rubus* spp.), nettles (*Urtica urens*), hazelnuts (Corylus avellana) and goose grass (*Galium aparine*), the latter species being available in the winter months (Robinson 2000: 88; Straker 1990: 216; Grime *et al.* 2014: 290). Vitamin C may also be derived from fresh meat, fish and sprouted grains, obtained from stored supplies (Brickley and Ives 2008: 42-43). Therefore, even though sources of vitamin C were less abundant in the winter months, milk, meat, stored grains and goose grass were valuable sources and evidence of these foods were excavated from Hazleton North long barrow (Straker 1990: 216). Furthermore, goose grass is a traditional remedy for scurvy (Brickley and Ives 2008: 43), but whether this was common knowledge in the Neolithic period cannot be ascertained.

What the evidence may confer though, is that the community did not recognise the importance of a varied diet and fresh plant foods for the young and vulnerable members of the group, even though they would have presumabably had adequate resources to do so. There may have been cultural taboos at work, with certain members of the community only being allowed access to certain foods. The fact that no members of the adult population (except for the pregnant women, nursing mothers, and other individuals responsible for feeding the infants) seemed to suffer from scurvy may be significant. However, shorter intervals between pregnancies as a result of the Neolithic transition to farming, where sedentism enabled earlier weaning of babies (Bocquet-Appel 2002: 647), may have contributed to micronutrient deficiency in mothers who were unable to replace depleted reserves in the inter-pregnancy interval (King 2003: 1735s).

Rickets

Rickets is a disease of childhood caused by the lack of vitamin D, and is characterised by skeletal deformity, retardation of growth, porous lesions and woven bone deposition (Kozlowski and Witas 2012: 405). Vitamin D may be derived from some foods such as eggs, liver and oily fish and fortified today in dairy products and cereals, but ninety per cent of an individual's requirement is synthesised by the body through absorption of ultraviolet light through the skin (Mays *et al.* 2006: 362; Holick 2006: 2065). Evidence of rickets in antiquity only comes from the 10th century, with an increase between the 16th and 19th centuries, due to urban pollution (Mays 2008a: 220). The disease was particularly prevalent among the poor inhabitants of cities during the industrial revolution, where access to daylight was restricted by smog, and the disease reached epidemic proportions.

William Macewen, a doctor working in Glasgow during this time, noted that the children of the city were "shut out from the light partly by the height of the houses [and] partly from the fact that even the sun's rays which do manage to struggle through the canopy of smoke which envelops them, are so diluted that they are of comparatively little value" (Macewen 1880: 14). Whilst the photographic images of children with bowed limbs from Victorian cities are a very striking reminder of the extent of rickets within the population at this time, the disease was also widespread during the seventeenth century, when England was at the centre of the wool trade. The demand for English wool required whole families to become involved in its production, entailing entire days spent inside, from dawn to dusk (Kellett 1934: 239).

However, there are no reports of the disease from the prehistoric period. The present study found a possible case of the disease from a child of approximately four and a half years of age from West Kennet long barrow. The right femur of the child has disordered swelling and flaring of the metaphysis and angulation of the growth plate, together with roughening, cupping and macroporosity on the diaphyseal bone underlying the epiphyseal growth plate, all indicators of the disease (Brickley and Ives 2008: 91; Mays 2008a: 216): The affected individual may have spent prolonged periods within the dwelling, either due to illness or disability, unable to absorb ultra-violet light from the sun's rays, the most efficient way of synthesising vitamin D. The fact that this is the only example of the disease from this period, would seem to suggest that environmental factors were not to blame.

Caries

Carious lesions of the teeth is the most common form of dental disease and involves the destruction of the outer enamel, inner dentine and the cement that covers the root (Hillson 2005: 290). There were 15 cases of dental caries in the present study, which affected at least ten individuals (5.2% CPR, 10/192) from nine sites (21%, 9/42). Sixty per cent of the carious lesions (9/15) were exhibited on the occlusal/crown surface, 20% (3/15) on the interproximal surface, and the other 20% (3/15) on the root (Figure 14.2).

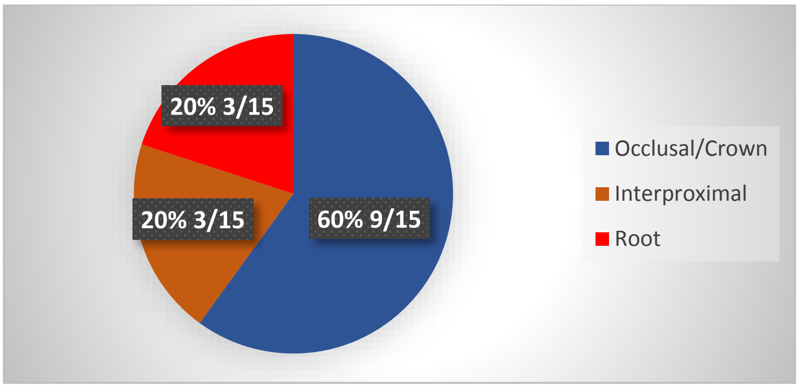


Figure 14.2: Percentage of carious lesions at sites.

The TPR for caries overall is only 0.7% (15/2111), and when the TPR is adjusted for sex, the rate for males is 0.3% (2/585) and 0.5% for females (3/384). These figures are low compared to the figures given by Roberts and Cox (2003: 69) at 3.3% (73/2208) and Brothwell and Blake's (1966: 60) data from Fussell's Lodge and other unspecified Neolithic sites at 3.12% (36/1151). However, the numbers of teeth assessed for Hazleton North long barrow have been mistakenly quoted as 180 by Roberts and Cox (2003: 69), when in fact Rogers (1990: 191) provides data for 494 permanent and deciduous teeth. Following re-analysis by the present author, it would appear that 53 teeth have been removed for testing or lost since the original analysis by Rogers in 1990 (the re-analysis recorded 441 teeth). Furthermore, one of the teeth with caries listed as # 11039 is missing from the assemblage. Nevertheless, the TPR given by Roberts and Cox of 3.3% is incorrect and should be amended to 2.9% (73/2522). Lawrence (2012: 529) reports a very low TPR for caries at Isbister of 0.4% (3/857). Galer (2007: 214) however, notes a much higher rate at Ascott-under-Wychwood where there were carious lesions on four dentitions, which affected 18 teeth, giving a prevalence rate of 8.1% (18/222). Whittle and Wysocki (1998: 162) report an absence of caries at Parc Le Breos, despite considerable wear on some dentitions.

The reason why the prevalence of caries varies between the studies cited is unclear. However, even though the only sugars exploited were from honey, fruits and berries, and carbohydrate from cereals in the Neolithic period, the introduction of farming had a dynamic effect on the rate of carious lesions. Recent research by Adler *et al*. (2013: 451) revealed the analysis of calculus deposits on the teeth of Mesolithic and Neolithic populations from Europe. The results of the study indicate that hunter-gatherers had a very low rate of caries, but the introduction of soft carbohydrate foods in the Neolithic period radically changed the oral climate of the population to a disease associated configuration (Adler *et al*. 2013: 453). The bacterial composition of the calculus deposits remained consistent until after the Medieval period, when the industrial processing of flour and sugar became popular (Adler *et al*. 2013: 453).

Calculus

Calculus is mineralised dental plaque and is principally composed of calcium phosphate (Waldron 2009: 240). The thick deposit accumulates on the teeth which are adjacent to the salivary glands, for instance, the lingual surfaces of the anterior teeth, especially in individuals who have a high protein diet, or one rich in alkaline favouring carbohydrate diets (Lieverse 1999: 219; Hillson 2002: 255). The degree of calculus deposits on the teeth of skeletonised human remains is a useful indicator of poor oral hygiene in past populations and is also useful for recreating palaeoenvironments and diet, ancient DNA and disease (Dobney and Brothwell 1986; Preus *et al*. 2011; De La Feunte *et al*. 2012; Warrinner *et al.* 2014).

The CPR for calculus at the 42 sites seems high, at 44.2% (85/192), and 12 sites had 100% of all individuals affected. However, 15 sites had no evidence of calculus at all, but this is entirely due to the fact that at four sites, there was no extant dentition. Males and females were similarly affected by calculus – 25 males and 12 possible males, compared to 25 females and six possible females. Unfortunately, it was not possible to calculate a TPR, as the condition was only recorded as present or absent. However, when the CPR is calculated by sex, the figures rise to 65% (37/57) for males and probable males, and 70.5% (31/44) for females and probable females.

Roberts and Cox (2003: 69) report a CPR of 11% (17/159) for calculus from nine sites and Lawrence (2012: 346) reports minor calculus deposits on the adult teeth from Isbister. Each tooth was recorded for deposits and none were assessed as heavy: 121 teeth had slight deposits; and 14 had moderate calculus deposits, with the first molar on both sides and on the maxillary and mandibular dentition exhibiting the most recurrent slight and moderate deposits of 44 and six teeth affected respectively. Lawrence (2012: 346) does not give a CPR or TPR for the condition, but records that there were 14 cases of the upper left first molar affected with slight deposits, indicating a CPR of 16.4% (14/85), with no apparent difference between the sexes for the condition. Whittle and Wysocki (1998: 162) note that some slight calculus deposits were present on several molars, but do not mention the number of teeth involved, or how many individuals were affected.

The present study, and that of Lawrence (2012), plus the data from Roberts and Cox (2003) report higher levels of calculus and lower rates of caries at sites. This indicates that the populations of the Neolithic were surviving on a high protein diet with minimal intake of carbohydrates, as the dental environment favourable for calculus is reliant on an alkaline pH, whereas caries are dependent on acid conditions (Lillie 1996: 140). This may also be linked to the surprisingly high prevalence of scurvy at Hazleton North long barrow (12%) and evidence of the disease at two others sites (Belas Knap and Fromefield) and the apparent widespread evidence of the scurvy at Isbister. The evidence from these sites indicates that not enough vitamin C was being consumed from fruits and plants. Stable isotope evidence gained from Neolithic human skeletal assemblages revealed that the diet was heavily reliant on protein gained from terrestrial sources (Richards and Hedges, 1999; Schulting and Richards, 2002).

Periodontal Disease

Periodontal disease is related to the lack of oral hygiene and is caused by inflammation of the soft tissues which surround the tooth (Waldron 2009: 240). The alveolar bone is eventually infected, resulting in resorption of the bone (Langsjoen 2011: 401). Periodontal disease is age-related and is very common in those individuals aged over 30 years (Hillson 2002: 267).

Roberts and Cox (2003: 70) report a CPR of 14% (13/93) of periodontal disease for the Neolithic at six sites, but the CPR for the present study is only 8.9% (17/192). Lawrence (2012: 341) reports eleven cases of slight periodontal disease in the maxillary dentition and nine cases in the mandibular; 14 cases of moderate disease in the maxillary dentition and 13 cases in the mandibles of adults; and eight cases of severe periodontal disease in the maxillary dentition, representing at least 33 maxillary dentitions, which gives a CPR of 39% (33/85). Lawrence suggests that scurvy is the cause of so much periodontal disease at Isbister (2012: 353).

The results of the present study found that more males than females were affected by periodontal disease, but a TPR could not be calculated as the condition was only noted as present or absent in individuals. However, when the CPR is calculated by sex, the figures rise to 17.5% (10/57) for males and probable males, and 15.9% (7/44) for females and probable females. It was noted that increasing age was also a factor. However, it may be significant that 29% of those affected (5/17) came from Hazleton North long barrow, and that periodontal disease at this site may be related to scurvy.

Ante Mortem Tooth Loss

Remodelled alveolar bone in the maxilla or mandible is indicative of ante-mortem tooth loss, the most common cause of which is periodontal disease, but other factors include trauma, extraction or scurvy (Lukacs 1992: 143; Waldron 2009: 238). Roberts and Cox report a TPR for the condition of 6.1% (87/1428) from nine sites, with more males than females affected (five males versus three females), and at Isbister, Lawrence (2012: 529) gives a TPR of 8.6% (185/2150). Galer (2007: 214) reports that ante mortem tooth loss was recorded in ten out of the 22 dentitions, affecting 8.1% of all tooth sockets (18/223). The assemblage from Parc Le Breos only produced evidence of ante mortem tooth loss in one mandible, and only one incisor was lost (Whittle and Wysocki 1998: 162), but no details of sex or age were given. The results of the present study give a TPR of 6.4% (197/3083), with at least 41 individuals affected (21.3%, 41/192). Slightly more males than females were affected (eleven males and seven possible males, versus nine females and six possible females, and eight unsexed individuals). However, when the TPR is adjusted for sex, it becomes apparent that females lost more teeth ante-mortem than males (Figure 14.3).

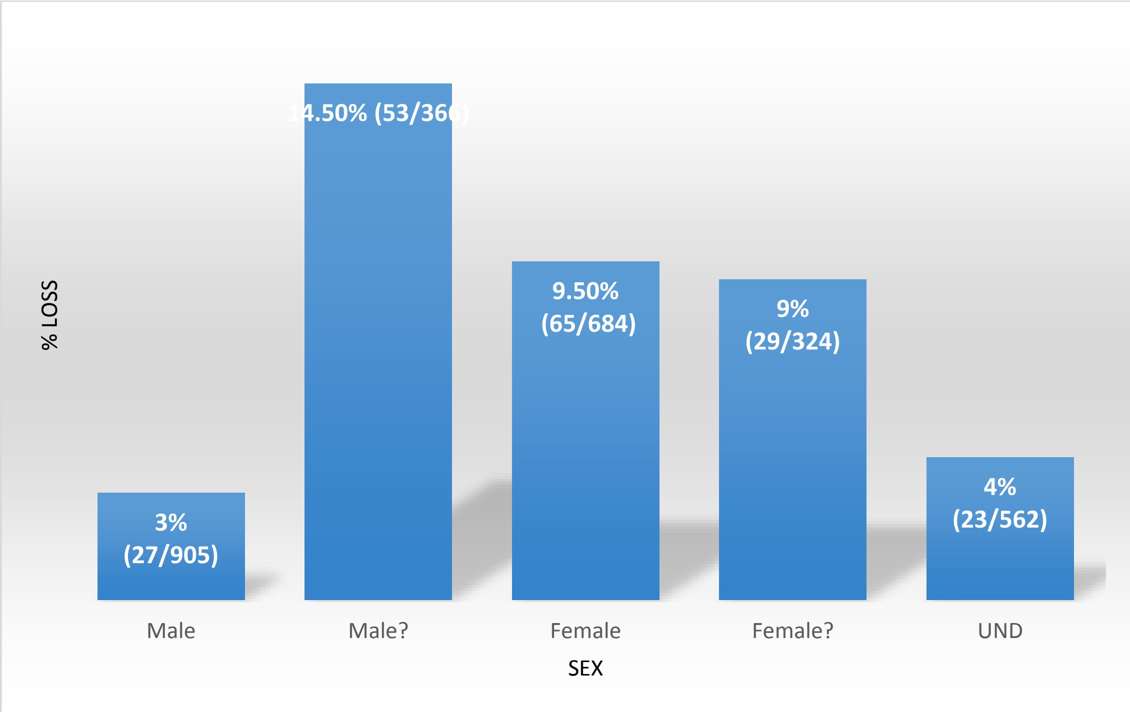


Figure 14.3: TPR by sex of individuals affected by ante-mortem tooth loss.

It may be significant that the site with the highest TPR for ante-mortem tooth loss is Hazleton North long barrow (Figure 14.4), which had a TPR of 16.6% (75/450). The assemblage from Hazleton North long barrow also had the highest prevalence rate for scurvy (four out of the six cases were from here, plus an unidentified individual who was responsible for feeding one of the infants), therefore maybe lack of vitamin C could have played a role for those individuals affected with ante-mortem tooth loss. However, 83% (10/12) of those affected also suffered from other dental diseases, which would have been a contributing factor, plus there was a high rate of dental wear among the individuals.

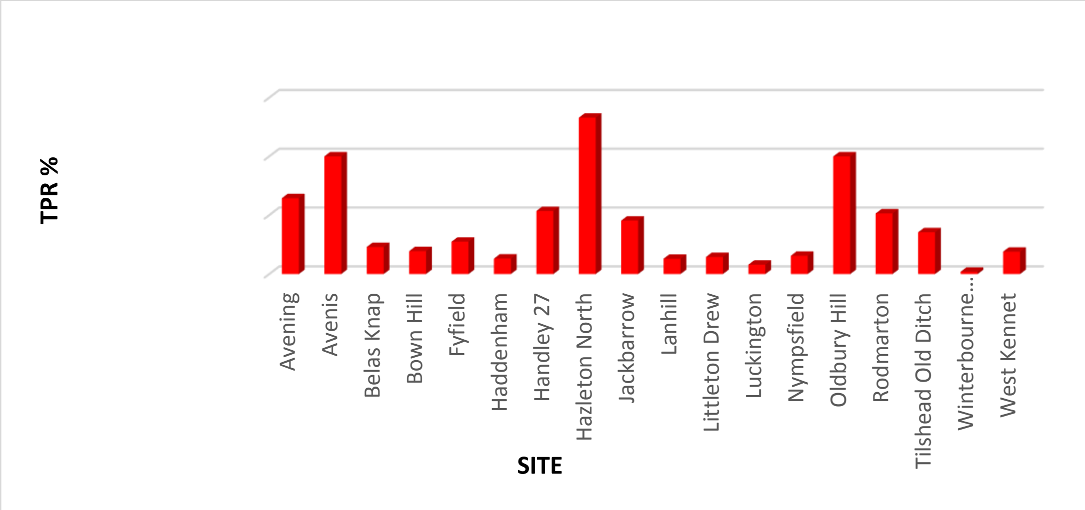


Figure 14.4: TPR% for ante-mortem tooth loss at those sites affected.

None of the individuals from Hazleton North long barrow with ante-mortem tooth loss were aged below 25 years, and in fact, most were aged over 40 years. All of the individuals (except for # 7474 and # 10213) had ante-mortem tooth loss in the posterior dentition, which is probably related to severe dental wear. However, the rate of ante mortem tooth loss at this site among individuals is very high compared to others of comparable numbers. Therefore, it is tentatively suggested that scurvy may have been a factor in the aetiology of ante-mortem tooth loss at this site. It is very difficult to recognise signs of scurvy on adult remains, because scorbutic porosity tends to be very diffuse (Mays 2008a: 223). However, by suggesting that vitamin C deficiency may have had a contributing role to the ante mortem tooth loss at Hazleton North, it may infer that the old, very young and even pregnant and nursing mothers were treated differently to the rest of the community. If so, it would seem that these vulnerable groups did not receive adequate vitamin C in their diet, which may be due to cultural reasons.

In accordance with Hazleton North long barrow, the majority of the individuals affected by ante-mortem tooth loss at other sites were aged in the Middle Adult category (35 - 50 years) and exhibited either total tooth loss or the posterior dentition was affected. Significantly, 75% (3/4) of the Young Adult category (25-35 years) all have lost dentition in the anterior arcade, suggesting perhaps that these individuals, like individual # 10213 from Hazleton North long barrow, lost a tooth from trauma, which may have been from a fall, or a blow to the face. In 16 individuals (57%, 16/28) there was no associated dental disease, although in some cases, this was due to the fact the arcade was mostly edentulous, and in and six cases, completely so (Avening #7; Avenis # 1950: 279; Luckington GC/D/1; Nympsfield # 63; West Kennet NW chamber # 15; and West Kennet SW chamber 63).

Whether ante-mortem tooth loss can be associated with scurvy at any of the sites other than tentatively suggested for Hazleton North is problematic, as there is a lack of evidence, other than at Belas Knap long barrow for the disease. Here, an infant (Individual 13F) from the site exhibited porosity and new bone formation in the orbit, which may possibly be indicative of scurvy. Therefore, it is tentatively suggested that the three adults from Belas Knap long barrow with ante-mortem tooth loss, and no other associated dental disease, could maybe have also been suffering from scurvy, although the degree of dental wear should be taken into consideration.

Dental Abscess

The development of dental abscesses is related to several factors: through trauma, attrition or dental caries, which can all exposure the pulp cavity, allowing bacteria to enter and pus to form (Dias and Tayles 1997: 551).

Roberts and Cox (2003: 69) report a TPR of 3.8% (83/2158) for dental abscesses in the Neolithic, and males were more affected than females (ten males versus three females). Lawrence (2012: 529) gives a lower figure for the condition at Isbister (1.3%, 27/2150). The assemblage from Ascott-under-Wychwood produced evidence of two dentitions with single abscesses: one in the maxilla of a child aged approximately eleven years (Galer 2007: 193); and the other in the mandible of an adult female aged between 33 and 45 years at death (Galer 2007: 208). Analysis of the dentition of the assemblages for the present study revealed that 12 sites had evidence of dental abscesses, and affected at least 28 individuals (CPR 14.6%, 28/192). The TPR is 2% (61/3083) overall, but when the TPR is calculated for sex, males show a higher prevalence than females for dental abscesses. Thirteen sockets out of 905 (1.4%) were recorded for males, and 4.1% was recorded for possible males (15/366). Only four sockets out of 684 were recorded for females (0.6%), and 1.5% for possible females (5/324). Unfortunately, 3.4% of the abscesses could not be assigned to a sex category and accounted for 19 out of 562 sockets. Finally, 2% of the abscesses were recorded in children (5/242) (Figure 14.5).

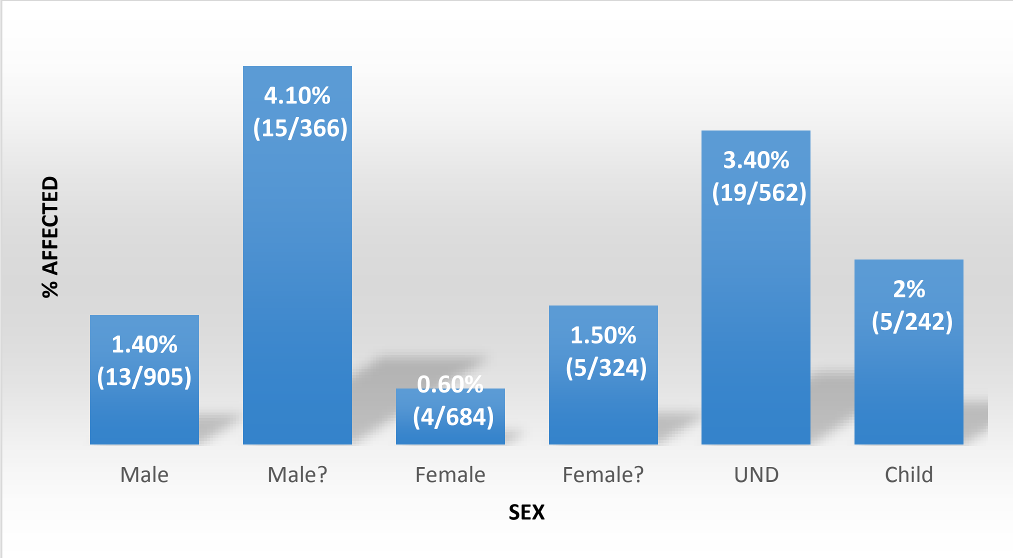


Figure 14.5: TPR for Individuals by sex with dental abscess.

Interestingly, the assemblage with the most individuals with dental abscesses is Hazleton North long barrow (39%, 11/28), where there is a strong link between dental abscesses, age and attrition. All of the adults from the site with abscesses, also exhibited severe attrition, and were in the Middle adult category (35-50 years). Only the two children from the site with abscesses have no other evidence of dental disease or wear, and both of the individuals had lesions in the anterior arcade.

The only individual who exhibited dental abscesses and a carious lesion was an adult female from Tilshead Old Ditch (EU.1.5.87), who also exhibited periodontal disease, calculus and ante-mortem tooth loss. The fact that this individual is female may perhaps account for the degree of dental disease exhibited. Lukacs and Largaespada (2006) conducted research into the effects of sex hormones on dental health, and found that the greater levels of oestrogen in females has a direct impact on oral health. The authors contend that the biochemical composition in saliva is different in females, and that hormone levels in females peak during pregnancy, and with each consequent pregnancy, further compromising oral health (Lukacs and Largaespada 2006: 549).

14.4.4: Infectious Disease

Osteomyelitis

Osteomyelitis is characterised by infection of the bone and bone marrow by pyogenic bacteria, resulting in inflammatory bone destruction (Resnick 2002: 2378). The bacteria can reach bone by three different routes: through haematogenous spread (the most common); by direct infection from penetrating injuries; or by direct spread from overlying infected soft tissue (Mast and Horowitz 2002: 232).

Only one individual, who could not be determined for sex, from the present study had evidence of osteomyelitis, (CPR 0.3%, 1/305, and a TPR of 0.9%, 1/106) in the form of a cloacal opening in the distal portion of a left adult fibula from West Kennet long barrow. The opening is surrounded by porosity and new bone, indicating increased vascularity in the area, and evidence of healing at time of death. The fact that no other individuals from the study had evidence of this condition could either mean that the evidence was fragile and was consequently fragmented, or anyone contracting such a virulent condition died of it quickly, before leaving any evidence on the skeleton. There were no reports of osteomyelitis from any of the other comparison sites.

Periosteal New Bone Formation

Periosteal new bone formation is often exhibited on the long bones in skeletal collections, in the form of woven new bone. It is caused by any mechanism that touches, breaks or stretches the delicate periosteum that covers the outer surface of the bone, and is not necessarily an artefact of infective processes, and may be caused by neoplastic disease or trauma (Richardson, 2001: Ortner 2008: 196).

Four disarticulated bones from two sites exhibited areas of periosteal new bone, and probably derived from just two individuals, who could not be determined for sex (CPR 0.7%, 2/305). All of the bones were from the lower limb: two adult fibulae had areas of periosteal new bone on the distal medial aspect, where the interosseous ligament attaches to the tibia (TPR 1.9%, 2/106); an adult tibia exhibits a large area of woven bone on the anterior aspect of the distal diaphysis (TPR 0.8%, 1/118); and an adult femur has an area of new bone on the posterior aspect of the diaphysis (TPR 0.9%, 1/115). Unfortunately, none of the bones could be directly associated with infection and may have been caused by trauma. Lawrence (2012: 381) reports that there were three axis vertebrae with areas of periostosis on the anterior of the body, which may have been linked to the fracture of some lower vertebrae. Three cases of periosteal new bone were noted by Galer (2007: 211) at Ascott-under-Wychwood long barrow on two metacarpal shafts and a tibia, but the aetiology of the condition was unclear and may have been related to trauma. Whittle and Wysocki (1998: 162) report three cases of periosteal new bone on the posterior of two femoral diaphyses, and these authors also underline the difficulty in discerning the cause of periosteal new bone in archaeological bone.

Otitis Media

Otitis media is an infection of the middle ear which most commonly affects children, but can last past childhood and become a chronic infection in adults, who can become re-infected through a perforated eardrum during bathing or swimming, or from nasopharyngeal secretions (Bluestone 1998: 214). In pre-Jenneran periods, otitis media would have been a serious infection, with a potentially fatal outcome. Complications of acute otitis media include: hearing loss due to destruction of the ear ossicles, which in turn has a negative impact on speech development; the increased risk of re-occurrence of the disease; perforation of the tympanic membrane; meningitis; and septicaemia (Daniel 1998: 143).

The present study revealed new evidence of otitis media in the Neolithic period for the first time. Five adult individuals exhibited macroscopic evidence of middle ear infection (new bone formation and porosity on the petrous temporal bone), three of which were verified by CT scan. A further individual was identified as having the condition after a CT scan was performed for another reason. Therefore, six individuals were identified with otitis media (CPR 2%, 6/305). Two of the affected individuals were male (33%, 2/6), and 50% were female (3/6), but the other individual was undetermined for sex (17%, 1/6). When the TPR was calculated by sex, it was clear that females had a much higher prevalence for otitis media than males. Only females were affected in the left petrous bone, giving a TPR of 6.3% (2/32). The right petrous bone was affected in two males, giving a TPR of 5.6% (2/36), and three females, giving a TPR of 10.3% (3/29) (Figure 14.6).

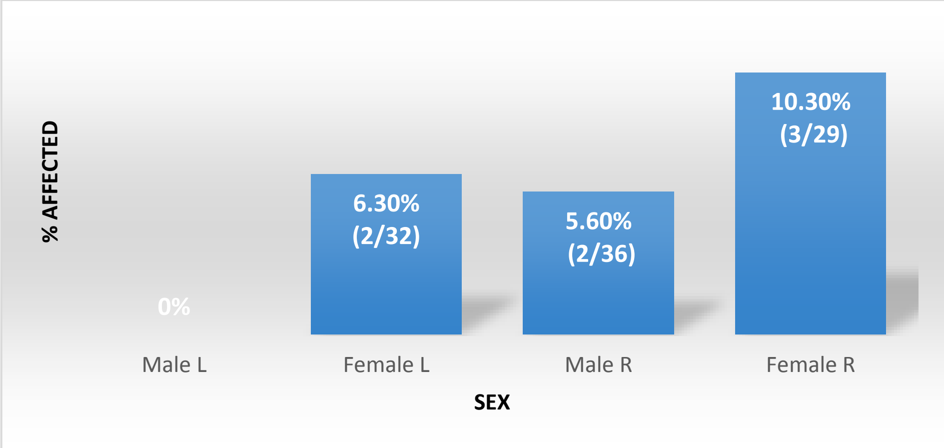


Figure 14.6: TPR by sex of individuals with otitis media in the left (L) and right (R) petrous bones.

The majority of the affected individuals were aged in the Middle Adult category (7.4%, 4/54 middle-aged adults) except for the individual from Bown Hill whose age was undetermined, and the female from Lanhill long barrow who was in the Older Adult category (4%, 1/23 older adults).

Three out of the six cases of the disease were excavated from Belas Knap long barrow and may suggest that genetic predisposition is a factor at this site. When the TPR was calculated, it was found that Bown Hill long barrow had the highest prevalence rate at 33% (1/3 MNI). Bruce *et al.* (2000: 1081) found that otitis media was associated with exposure to smoke from open fires, which in the Neolithic period may have been a more confined experience than in former times.

Evidence of Neolithic houses in England are fairly rare, unlike the more numerous examples excavated in Ireland, Scotland and Wales (Bradley 2007: 38). However, the recent discovery of a dwelling in Yarnbury, North Yorkshire, gives insights into house building in the Early Neolithic period. The rectangular house measured 10m on the longest axis, and was constructed of oak posts, with small calibre hazel Roundwood used for wattle panelling (Gibson 2017: 201). The house was split into two separate sides, and a hearth was excavated from the floor of one of the “rooms” (Gibson 2017: 195). The evidence from Yarnbury highlights that dwellings at this time were not very large, and exposure to noxious fumes from the open fire would have been unavoidable. The fact that females had a much higher prevalence than males for otitis media, and in the cases of the individuals from Lanhill long barrow (EU.1.5.105) and Rodmarton (# 80), the condition was bilateral, may suggest that susceptibility to the disease may be partially explained by cultural practices. Perhaps it was the role of women to tend the fires and cook the food, as is the case in many developing countries today (Bruce *et al.* 2000: 1080), thereby exposing them to harmful fumes on a daily basis.

The CT scans of the middle ear showed that the affected individuals had chronic otitis media, sustained over a long period, and in the case of the female adult from Belas Knap long barrow (# 8), the damage was so profound, that it would have resulted in deafness.

Meningitis

Meningitis is the inflammation of the meninges of the brain and spinal cord and is a very serious illness, with significant levels of morbidity and mortality today (Nudelman and Tunkel 2009: 2578). In pre-Jenneran times, it is unlikely that anyone affected could have survived such an infection for any length of time, although the disease may have been less virulent than it is today. One individual from the present study is suspected of having meningitis. The adult male, from Belas Knap long barrow (# 6) was also suffering from chronic otitis media, and exhibits two large plaques of woven bone on the endocranium, adjacent to the left orbit. The fact that the individual survived long enough to have an inflammatory response to the infection, may suggest that he had a strong immune system, due to the chronic nature of the re-occurring otitis media, or perhaps the infection was not as virulent as that found in modern populations (Roberts and Cox 2003: 65). To date, only one other adult and two infants have been inferred to have been suffering from meningitis. These individuals were excavated from Hambledon Hill, a Neolithic complex in Dorset, and were found to have endocranial new bone formation, which McKinley (2008: 510) attributes to an infection of the dura mater. Therefore, the evidence from Belas Knap long barrow and Hambledon Hill attest to the antiquity of meningitis in Neolithic populations, albeit that the disease was rarer than it is today.

Poliomyelitis

Poliomyelitis is a viral infection which is spread person to person via the faecal-oral route, and causes paralysis if the virus enters the central nervous system, damaging the horn cells of the spinal cord and brain stem (Nathanson and Kew 2010: 1213; Mehndiratta *et al*. 2014: 225). One individual from the present study may have suffered from poliomyelitis. An adult male from Hazleton North long barrow exhibits a very gracile right forearm compared to the left, which has lost muscle definition along the interosseous border of both the affected radius and ulna. In addition, the radius has a well-healed Colle's fracture to the distal diaphysis, and the ulna has a healed parry fracture to the distal diaphysis. The fractures may be pathological, as the bones are very gracile and may be osteoporotic, caused by diffuse atrophy following paralysis of the limb. The difference in length of the limbs is not very significant, and may suggest that this individual contracted poliomyelitis during the adult years, when growth was complete. Evidence of spinal scolosis is also present in this individual. Although no vertebrae were extant, the sacrum exhibited unilateral and unsymmetrical sacralisation of the fifth lumbar vertebra.

A small number of cases of poliomyelitis from Britain have been reported in the palaeopathological literature, with one other possible example from the Neolithic period. Rolleston describes an adult male excavated from Cissbury flint mine, West Sussex. The individual exhibited shorter upper and lower limbs on the left side, and was considered by Rolleston (1879: 384) to be suffering from poliomyelitis. This individual, though, is considered to have partially recovered from the paralysis affecting the limb. Even though the limb is shorter, is was not noticeably more gracile than the right, suggesting that this individual contracted poliomyelitis during the childhood years (Rolleston 1879: 384). An adult male from Barton Bendish, Norfolk, dating to the Bronze Age was considered by Wells (1964: 92) to be suffering from the disease, due to atrophy of the left limb. Another male, dated to the eighth to tenth century AD from Raunds, Northamptonshire, exhibited shortening and atrophy of the right lower limb, which was attributed to poliomyelitis (Roberts and Manchester 2010: 181). Finally, a male from Medieval Norwich was considered to be suffering from the disease, due to atrophy of both lower limbs, together with scoliosis of the spine (Stirland 1997: 589).

14.4.5: Joint Disease

Osteoarthritis

Osteoarthritis only affects the synovial joints and is characterised by the formation of marginal osteophytes, reactive subchondral bone in the form of eburnation, sclerosis and cysts, pitting on joint surfaces, and alterations to joint contours (Rogers *et al.* 1987:

185). The aetiology of the disease is unclear but contributing factors include age, genetic disposition, sex, race, obesity, trauma and activity (Rogers and Waldron 1995: 32).

At least 23 individuals (7.5%, 23/305) from 16 sites (38%, 16/42) had evidence of osteoarthritis. Seventy per cent (16/23) of the individuals could be assigned a sex category, which could be separated into eight males and one probable male, six females and one probable female. More males than females appeared to be affected by osteoarthritis, which does not follow the pattern in modern populations, where females are generally more affected than males (Rogers and Waldron 1995: 32). However, when the TPRs were calculated by sex, females had a higher prevalence of osteoarthritis than males in some of the joints where a direct comparison could be made. Females had a higher prevalence than males in the hip (8.3%, 1/12 versus 7.1%, 1/14 on the proximal femur) and 17% (1/6) versus 8.3% (1/12) on the ossa coxae. However, the female was only affected on the left side, and the male on the right, so a comparison in this case may not be valid. The sterno-clavicular joint was affected in 100% (1/1) of females and 10% (1/10) of males on the manubrium, but the right clavicle was affected in 5.9% (1/17) of females and 6.25% (1/16) of males. However, males had a higher prevalence of osteoarthritis in the shoulder, with 9.1% (1/11) versus 5.3% (1/19) of left clavicles affected, and 11.8% (2/17) for the right versus 6.25% (1/16) in females.

In total, 54 joints were affected by osteoarthritis, and the joints with the highest prevalence were the apophyseal joints of the spine 17% (9/54), the temporomandibular joint 15% (8/54) and the atlantoaxial joint of the cervical spine 15% (8/54), and the least affected was the ankle joint 1.8% (1/54) (Figure 14.7).

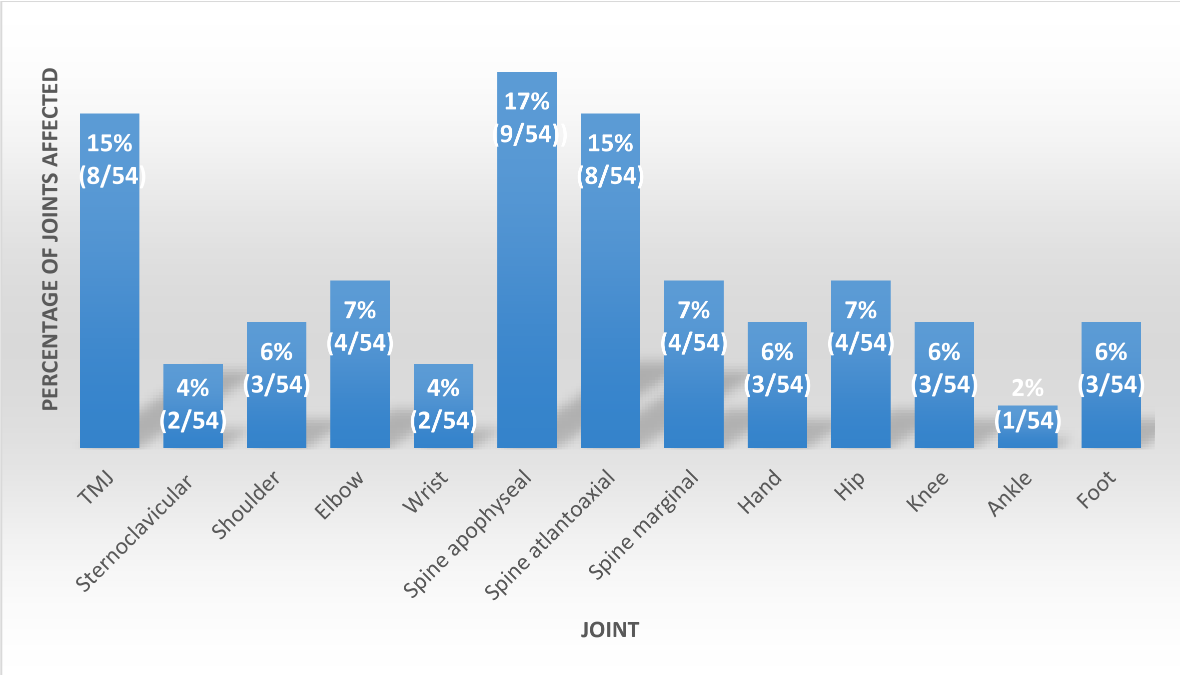


Figure 14.7: Percentage of joints affected by osteoarthritis.

Seven individuals (2.3%, 7/305) had evidence of osteoarthritis in more than one joint. All of these individuals, except the probable female from Wor barrow (Skeleton 5) had osteoarthritis of the spine, but this individual did not have any extant vertebrae to examine. Three of the individuals (43%, 3/7) had osteoarthritis of the shoulder, and two (29%, 2/7) had osteoarthritis of the sternoclavicular joint. However, Skeleton # 2, an adult male from Hazleton North long barrow may have been the most affected by the disease. This man has evidence of osteoarthritis in the spine, right hip, knee and foot, probably limiting mobility and causing a degree of discomfort, together with a stiffness and limited range of movement in the neck.

The prevalence of osteoarthritis at Isbister was reported to be widespread, affecting most of the joints (Lawrence 2012: 264). Figure 14.8 details the prevalence of osteoarthritis at Isbister (by side) to give a comparison with the present study, although it is unclear whether the data given by Lawrence is a TPR or CPR. The data from the present study uses the CPR, and only the joints that are directly comparable are listed. It is clear that there was a higher degree of the disease at Isbister than from the 42 sites in the present study, except on the right elbow. Lawrence asserts that the high prevalence of osteoarthritis at Isbister is due to heavy labour and trauma (Lawrence 2012: 303) but he does not separate out the figures for primary and secondary osteoarthritis.

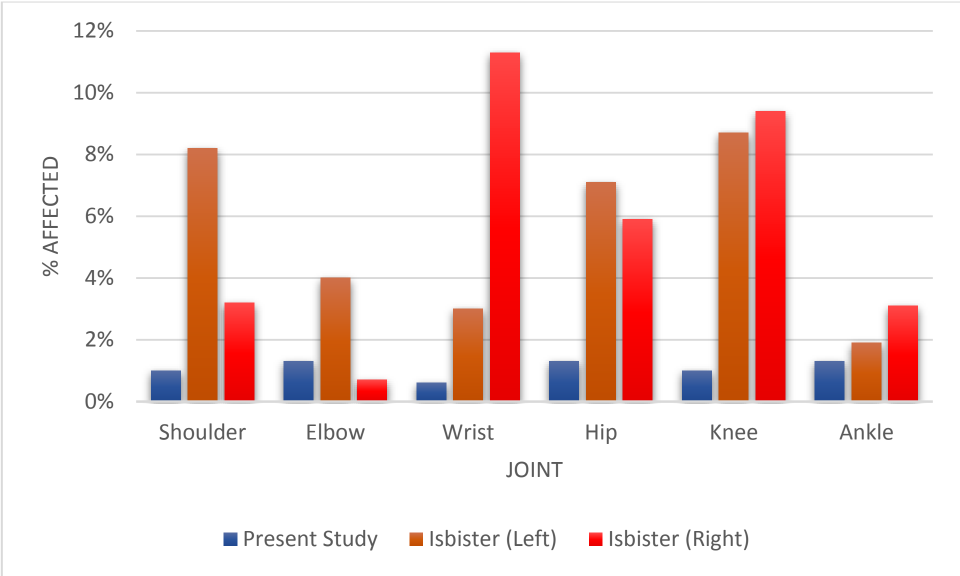


Figure 14.8: Prevalence of osteoarthritis at Isbister (brown = left side; red = right side) and in the present study (blue).

The differences in the prevalence of osteoarthritis between the present study and that from Isbister is very dramatic, and cannot be explained by the number of adults interred within the different monuments. It might be expected that there was a greater number of adults excavated from Isbister, but the reverse is true. The present study recorded the presence of 69 young adults, 54 middle adults, and 23 old adults, plus 77 that could be assigned an age category, giving a total of 223 adults. However, according to Lawrence (2012: 202) there were 38 adults and 13 young adults, based on cranial age at Isbister, but the figures are slightly different based on mandibular age – 12 young adults and 39 adults. Therefore, it is unclear what factors are affecting the difference in the figures, except perhaps in the recording methods.

The evidence from Ascott-under-Wychwood long barrow for osteoarthritis was low, and was most severley exhibited in a left trapezium which was eburnated. However, the disease was also present in two shoulder joints (and four acromioclavicular joints), four sternoclavicular joints, four pedal phalangeal joints, and the apophyseal joints of the vertebrae (Galer 2007: 212).

DISH

Diffuse Idiopathic Skeletal Hyperostosis (DISH) is characterised by the proliferative vertical osteophytes that flow down the anterolateral aspect of the vertebral bodies

(Resnick 2002: 1477). In addition, enthesophytes will be evident on the skeleton and ossified cartilage may also be present (Rogers *et al*. 1987: 188). Clinical and palaeopathological studies have shown that there is a strong correlation between DISH, obesity and diabetes and that more males than females are likely to be affected (Waldron 2009: 74; Julkunen 1971: 611; Rogers and Waldron 2001: 361).

Rogers (1990: 194) tentatively suggests that Skeleton A from Hazleton North long barrow has DISH but was unable to prove the case because the sacroiliac joints were missing. However, re-analysis of the bones of this individual provides compelling evidence for DISH, the only case from the Neolithic period.

Skeleton A from Hazleton North long barrow is a mature adult male, aged between 23 and 57 years of age who has osteoarthritic changes to the wrist, clavicles, and cervical vertebrae. This individual has flowing enthesophytes on the right side of the anterior bodies of the existing two contiguous thoracic vertebrae, and the joint space has been spared between the vertebral bodies. Furthermore, all five lumbar vertebrae are fused, with flowing enthesophytes running vertically down the anterior bodies on the left side, and the joint spaces between the vertebral bodies are unimpaired. In addition, this individual has enthesophytes on both patellae (insertion for *M*. *quadriceps femoris*, the left calcaneus (insertion for Achilles tendon), both pubic tubercles, the posterior of the right pubis (insertion for *M*. *obturator externus*), the right proximal fibula (insertion for *M*. *peroneus fibularis*), and ossified costal cartilage of a fragment of rib.

Further evidence that this individual was likely suffering from DISH is supported by the fact that he was also suffering from septic arthritis, a condition caused by the infiltration of bacteria into a synovial joint. Individuals who are susceptible to both DISH and septic arthritis include those suffering from diabetes. Furthermore, the fact that Skeleton A has septic arthritis of the joint between the second and third metatarsal of the left foot, may suggest that, like many sufferers of diabetes, he had sensory loss to the foot and would therefore be more likely to injure the lower extremity, perhaps whilst walking barefoot.

Degenerative Conditions of the Vertebral Column

Intervertebral disc disease is a progressive condition linked to individuals aged over 40 years, and is characterised by enthesophyte formation on the margins of vertebral bodies and pitting on the superior or inferior surfaces of the bodies (Burt *et al*. 2013:

57; Rogers and Waldron 1995: 27). Intervertebral disc disease should not be confused with osteoarthritis of the spine as it does not involve the suite of changes seen with that condition, such as porosity, joint contour change and eburnation (Resnick 1985: 6).

There was a surprising lack of evidence for this condition in the study of 42 sites for this project. Only five vertebrae from three sites had pitting and marginal enthesophytes on the vertebral bodies. At Isbister, Lawrence (2012: 275) reports "DJD was noted throughout the spine (i.e. on articular facets of all types). Schmorl's nodes osteophytosis, articular pitting, lipping and eburnation were all recorded. The recovery of thoracic and abdominal elements was very poor and fragmentation high, so that no estimates of prevalence distribution through the spine were considered practical."

Galer (2007: 211) reports that there were five cases of Schmorl's nodes present at Ascott-under-Wychwood, which were found on one thoracic and four lumbar vertebrae. Smith and Brickley (2009: 129) note the presence of a Schmorl's node on a lumbar vertebra from Adlestrop long barrow.

The current study found that five sites had evidence of Schmorl's nodes, affecting at least five individuals (1.6%, 5/305), which again is a very low prevalence, but Roberts and Cox (2003: 73) report a CPR of 7.6% (10/131) for the Neolithic period. The reasons why degenerative disc disease and the presence of Schmorl's nodes in the assemblage is under-represented in this study is probably due to the lack of vertebrae retained following excavation. In total, there were only 180 cervical, 411 thoracic and 183 lumbar whole vertebrae available for examination. This accounts for only 8.4% (180/2135), 11% (411/3660), and 12% (183/1525) of the expected total (out of a MNI of 305). Thirty-two of the sites had no whole vertebrae at all, accounting for 76% (32/42) of the total, the reasons being either damage during excavation, taphonomic, or worse, being left in the monument as these elements, along with many others, were considered unimportant by the excavators who seemed to prize crania above everything else. However, this does not fully explain why the presence of Schmorl's nodes on the extant vertebrae was not more prevalent.

14.4.6: Congenital and Developmental Disorders

Extra Ossicles

Extra ossicles or Wormian bones are found within the sutures of the cranium but are non-life threatening and can be useful to infer familial relationships (Berry and Berry 1967: 361; Sanchez-Lara *et al*. 2007: 3248).

Fourteen individuals (13 adults and one child) from seven sites had extra ossicles, giving a CPR of 4.6% (14/305). There was a significant difference in the ratio of males and females with the condition – 18.2% TPR for females and probable females (6/33), compared to 15.9% for males and probable males (7/44). Four sites had more than one individual with extra ossicles, and in three of these (Belas Knap, Littleton Drew, and Winterbourne Monkton) two individuals had the same wormian bone in common, tentatively suggesting a family relationship: Belas Knap #10 and Belas Knap # A1 both have a lambdoid ossicle; Littleton Drew #54 and Littleton Drew # 59 both have an apical bone; and Winterbourne Monkton # 29 and Winterbourne Monkton # 32 both have an Asterionic bone.

Two individuals had two extra ossicles, but an adult male from Gatcombe Lodge long barrow had five extra ossicles. In addition, he has a suite of minor abnormalities in the form of several non-metric traits, and defects of two developmental fields, suggesting that this individual suffered from an unidentified syndrome (Spranger 1982: 163). The five extra cranial ossicles and a retained metopic suture are field defects of the blastemal desmocranium. A precondylar tubercle was present on the occipito-cervical border of the cranial base, which is a para-axial mesoderm developmental defect. In addition, he suffered from severe dental erosion on the occlusal surfaces of the mandibular molars, due to gastroesophageal reflux disease. The lack of any post-cranial bones has hampered any further investigation into a possible classification of the type of syndrome that this individual may have been suffering from.

Lawrence (2012: 245) reports that extra ossicles were common at Isbister and details 28 of these anomalies in both sexes and children. However, it is not clear whether some individuals had more than one ossicle, but apparently there was no bias in the distribution between the sexes (Lawrence 2012: 245).

Extra Sutures

Four individuals exhibited an unfused metopic suture, which is caused by a developmental delay of the precursors of the frontal bone (Barnes 1994: 148). All of the individuals were males or probable males, including the adult from Gatcombe Lodge who exhibited five extra ossicles. Two of the male individuals were from West Kennet long barrow (EU.1.5.140 and EU.1.5.62), perhaps suggesting a familial relationship, but this is only the case in 5.6% of people with the condition (Graham and Sanchez-Lara 2016: 218). Lawrence (2012: 250) reports that one child had a retained metopic suture.

Two individuals had a retained mendosa suture, which is caused by the failure of the supraoccipital and the interparietal portions of the occipital bone to unite before birth (Barnes 1994: 142). Both of the individuals were male or probable male but were excavated from different sites.

Sutural Agenesis

One individual exhibited evidence of sutural agenesis in the form of scaphocephaly, which involves the failure of the sagittal suture, resulting in an elongated and narrow cranial vault (Sadler 2015:148). The young adult female was excavated from West Kennet long barrow (EU.1.5.148) and may have suffered moderate speech and language difficulties, together with mild neurocognitive deficits (Graham and Sanchez-Lara 2016: 202). There was a high prevalence of craniosynostosis recorded at Isbister, where eleven juveniles aged between four and eleven years at death were considered to have the condition – three were classed as plagiocephalic and two as trigonocephalic (Lawrence 2012: 250).

Congenital Muscular Torticollis

Congenital muscular torticollis is associated with a difficult birth and is caused by the shortening of *M*. *sternocleidomastoid* on one side of the cranium, which tilts the head towards the affected side (Skinner *et al.* 1989: 26). The condition may also be caused by abnormal fetal positioning *in utero* (Nilesh and Mukherji 2013:198). One individual in the current study presents with a compelling case of congenital muscular torticollis, an adult male from Wor Barrow (#4), in the form of a twisted cranial vault, twisted cranial base, asymmetrical occipital condyles, mastoid processes, and mandibular fossae, together with a deviated ascending ramus of the mandible on one side. This individual would have had a noticeably different appearance to others in the community.

Klippel-Feil Syndrome

Two individuals exhibited this developmental defect, which is caused by segmentation failure of the spine between the third and eight week of morphogenesis (Resnick 2002i: 4602). Neither of the individuals could be determined for sex but would probably have had a shortened neck and limited ability in movement.

Sacralization of the Fifth Lumbar Vertebra

An adult male and one female adult exhibited sacralization of the fifth lumbar vertebra, which is caused by cranial shifting at the lumbosacral border, giving a CPR of 0.7% (2/305). The TPR for this element reveals that females had a higher prevalence of this disorder than males - 11% for females (1/9) and 6.25% (1/16) for males. A female from Lanhill long barrow (EU.1.5.107) had bilateral symmetrical sacralization, which would not have had an adverse effect on her appearance or movement. However, the male adult from Hazleton North long barrow (Skeleton D) has unilateral, asymmetrical sacralization which has not fused on the right side, causing the sacrum to lean laterally. In consequence, this individual would likely have had suffered a curvature of the lower back. There was one case of sacralization of the fifth lumbar vertebra at Isbister, which had asymmetrical sacralization on the left side (Lawrence 2012: 296).

Spina Bifida Occulta

One adult individual from Luckington long barrow (# GC/D/5) exhibited spina bifida occulta to the sacrum, in the form of an open sacral canal between S2 and S5. The defect is caused by failure of the neural arches to close, but unlike spina bifida cystica, the condition is asymptomatic (Aufderheide and Rodríguez-Martin 2011: 61). There were two individuals from Isbister that exhibited spina bifida occulta (Lawrence 2012: 257), and three cases from Ascott-under-Wychwood (Galer 2007: 210).

14.4.7: Neoplastic Disease

Osteoma

Five individuals (1.6%, 5/305) from four different sites exhibited button or ivory osteomas in the current study, which are composed of woven and compact bone, and present as a shiny and circular shallow protuberance on the parietals and frontal bones of the cranium. All of those with an osteoma were male, with one probable male, which conforms to the pattern seen in most skeletal assemblages (Aufderheide and Rodríguez-Martin 2011: 375). There was one example of osteoma from Isbister, exhibited on an adult male (Lawrence 2012: 383), and Roberts and Cox (2003: 62) report that two cases are known from the Neolithic period, but do not specify where the examples were excavated from.

Chondroblastoma

One individual exhibited a possible chondroblastoma of the proximal end of the left humerus. The tumours are fairly small in diameter and only arise in the epiphysis of the humerus, femur and tibia (Turcotte *et al*. 1993: 947). Lawrence (2012) does not report any cases of chondroblastoma but details a slow growing benign tumour of the maxilla in an unsexed adult, together with two cases of benign slow-growing lesions in the calcanei of two adults (Lawrence 2012: 390-392).

Malignant Tumours

One individual, a child from Avenis long barrow exhibited lytic lesions on cranial fragments that may be indicative of malignant neoplastic disease. The lesions are present on the ectocranial and endocranial surfaces and are consistent with the morphology of the lesions in metastatic cancer (Amaral *et al*. 2003: 532). It is significant that this finding is the first case of metastatic cancer for the Neolithic period. It is impossible to state which type of primary tumour that the cancer has spread from, due to the lack of any post cranial bones, but the possibilities include Ewing’s sarcoma, osteosarcoma, neuroblastoma, leukaemia, or Langerhans cell histiocytosis.

There was one interesting case of malignant neoplastic disease from Isbister, in the form of multiple myeloma. The adult male exhibited small lesions on the cranium, and eleven other elements that probably belonged to this individual (Lawrence 2012: 387).

The current knowledge of the health of the people of the Neolithic period has been augmented by this research and is the most detailed and up-to-date account of the diet and health of the inhabitants of southern Britain at this time. What is also apparent from the study of the human skeletal remains in the current study is the degree of pathological conditions present. The MNI can only represent a small fraction of the population in the Neolithic period, yet the evidence of infectious, joint, dental, neoplastic, and metabolic diseases present seems to be out of proportion to what might be expected if this was a representative sample of the population. In addition, the degree of congenital and developmental disorders (which contributed in some cases to differences in appearances) and non-specific indicators of stress evident in the collection is also very high. Therefore, a high proportion of those interred within Neolithic monuments would seem to have withstood a great deal of suffering, and maybe this is the real reason for their inclusion within. Many of the diseases evident were chronic in nature, and perhaps imbued the sufferers with an aura of strength, thereby elevating their status and ensuring commemoration within the tomb. These individuals could therefore be perceived to offer protection to the remaining community. Conversely, it may have been the case that the individuals chosen for inclusion within the tombs were considered to have been unlucky, polluting, or suspicious, due to extended periods of illness. It was therefore deemed prudent to place these individuals in a sealed tomb, out of harm's way.

Whether the former or latter scenario is the more likely to conform to the pattern of burials seen in Neolithic monuments, it would appear that interment within the tomb was not dependent on age or sex, but perhaps preferentialy granted to those individuals who were "different". Maybe the trial of having suffered pain or deformity in life was the reason these individuals were chosen.

14.5 Trauma

Can the patterns of traumatic injuries to bone add to the growing corpus of knowledge on the increasing propensity for violence in the Neolithic period?

14.5.1 Axial Skeleton

Cranial Vault Fractures

Fractures that are inflicted upon the cranial vault tend to be caused by direct trauma, either in the form of accidental fracture from a fall, or by interpersonal violence (Lovell 1997: 149). Eight individuals were considered to have suffered from cranial vault fractures, five of which were received peri-mortem, and three were healed injuries. Four of the cases of peri-mortem fracture had already been discussed by other researchers but one new case was presented from Belas Knap long barrow. The adult male exhibited a depressed fracture to the left parietal, with three radiating fractures, and no sign of healing, and all of the injuries were sustained above the HBL, indicative of a blow to the head by a right-handed assailant (Kremer *et al*. 2008: 717).

The three cases of healed cranial vault trauma were presented for the first time. An adult female and two adult males all had a healed depressed fracture to the right frontal bone, superior to the orbit. The injuries suggest that these individuals received blows to the head from a right-handed attacker, in a face-to-face confrontation. In some cases, it is possible to suggest the weapon used to inflict such injuries. Recent research by Smith *et al*. (2011) involved the use of flint arrow heads on animal bones to assess the patterns of damage. The results from this study confirmed an earlier theory by Smith and Brickley (2009: 106) that the wound sustained by the individual from Littleton Drew (EU.1.5.53), and a similar one from an individual from West Tump, were from arrowheads, probably fired from above. As well as arrows, polished stone axes and club-like weapons are favoured by Schulting (2012) as likely candidates to inflict the type of cranial injuries seen from this period.

Lawrence (2012: 339) describes eight cases of cranial vault trauma which have been sustained during interpersonal violence at Isbister: three were cases which had multiple fractures, sustained during a close contact assault; two crania had circular penetrating wounds, perhaps inflicted by hand weapons; two crania were considered to have suffered sharp force trauma; and the last is listed as blunt force trauma. Smith and Brickley (2009: 109) also report on a case of cranial trauma inflicted upon an adult from Bowl's barrow, who exhibits radiating fractures consistent with a blow to head delivered with considerable force.

Nasal Fractures

One elderly female from Lanhill long barrow had received a fracture to the left nasal bone, which had healed but projects anteriorly to the adjacent frontal process of the maxilla. This individual also has a healed fracture to the adjacent inferior orbital rim. The location of the nasal fracture implies that the injury was inflicted by a lateral blow to the nose, possibly fracturing the inferior left orbital rim simultaneously, and may have been delivered by a right-handed attacker (Galloway and Wedel 2014a: 150-151).

Zygomatic Fractures

Three individuals suffered fractures to the zygomatic bone, which is a commonly fractured bone in the facial region due to its prominent position, often fractured in assaults (Tadj and Kimble 2003: 49). All of the injuries were healed at time of death, and were inflicted upon an adult male, an elderly adult female and a probable adult female. The elderly female also received a fracture to the nasal bone (see above section) and the blow to the right zygomatic process resulted in a triple fracture. The probable female also had a fracture to the right zygomatic bone, which had broken at the frontal process and the temporal process. Both of these injuries may have been sustained in a face to face attack by a right-handed assailant. The adult male sustained a fracture to the left zygomatic process, which had healed but there was non-union between the two fractured portions of bone.

Fractures of the Clavicle

Only one individual exhibited a fractured clavicle, which had healed ante-mortem. The adult female from West Kennet long barrow sustained the fracture to the mid-diaphysis of the bone, which exhibited an overlap where the two ends of the break met, twisting the shaft slightly. In past populations, this type of fracture could commonly be sustained during a fall or by violent means (Robinson 1998: 481).

Rib Fractures

Only two examples of fracture to the ribs were found in the current study. Both of the rib fragments were from Hazleton North long barrow and one belonged to an adult and the other to a child. Both fractures were healing at time of death. It is very surprising that there were only two examples of a rib fracture, but this may have to do with the fact that ribs are very fragile, and on many sites, were not retained. Lawrence (2012) does not report any rib fractures at Isbister, and perhaps for the same reasons.

Vertebral Fractures

There were only two vertebrae with fractures, both exhibiting compression fractures. Neither bone could be assigned to a specific skeleton, but were excavated from West Kennet long barrow (lumbar vertebra) and Hazleton North long barrow (thoracic vertebra). There is evidence of interpersonal violence at Isbister in the form of penetrating injuries to three vertebrae, which have resulted in fractures. Four more vertebrae (one lumbar and three thoracic) are reported to have suffered crush fractures, either as a result of trauma, osteoporosis or heavy labour (Lawrence 2012: 316-317). Galer details a case of healed trauma of an atlas and axis, which caused a dislocation. The fracture had healed and had ankylosed, thereby stabilising the joint (Galer 2007: 212). An arrowhead injury to a lumbar vertebra was also found at this site. A projectile point was embedded in the right lateral side of a third lumbar vertebra and was considered by Knüsel (2007: 218) to have delivered during an ambush-type attack.

14.5.2 Upper Limb Fractures

Humerus

One individual, an adult from Rodmarton long barrow, exhibited a peri-mortem spiral fracture to the mid shaft of the left humerus. The edges of the fracture are sharp and irregular and there is a conchoidal impact scar to the lateral surface where the bone was struck from the side. Unfortunately, this was a disarticulated bone which was not allocated to a specific individual, so revealing evidence of peri-mortem trauma on the rest of the skeleton was not possible. However, the humerus is very gracile and the measurement of the head is 39.7mm, which is small, even for a female. Another female from the same site had suffered a peri-mortem linear fracture to the cranial vault, possibly inflicted with a sharp implement like a stone axe, and it is possible that the humerus belongs to the same individual.

An adult male from Lanhill long barrow had suffered a traumatic injury to the left elbow, possibly during the growth years, that has deformed the joint. The left upper limb is much more gracile than the right and probably had very limited movement, causing the muscles to atrophy.

Radius

There were two individuals who had suffered a radial fracture, an adult female from West Kennet long barrow, and an adult male from the same site. The female had well-healed Colles' fracture to the left distal radius and the male had a well-healed oblique fracture to the mid-shaft that is not in perfect alignment due to displacement of the two broken ends. Isbister had more evidence of radial fractures from six individuals. All of the fractures were well-healed at time of death: one was a transverse, oblique or spiral fracture to the diaphysis; three were Colles' fractures; another had trauma to the wrist with subluxation of the carpus and a fractured styloid process; and the last injury was to a proximal diaphysis. Lawrence (2012: 323) considers all of the fractures to have been caused by falls, where the individual fell onto an outstretched hand. There was also a healed Colle's fracture on a left radius excavated from Ascott-under-Wychwood long barrow (Galer 2007: 202).

Ulna

Two individuals (a male from Hazleton North long barrow and a probable male from Haddenham long barrow) exhibited possible "parry" fractures on the distal half of the ulna. These injuries are inflicted by a blow to the forearm, as the individual attempted to block a blow to the head, and are direct evidence of interpersonal violence. However, Judd (2008: 1664) cautions that this type of injury may have been over-diagnosed in the past and wrongly attributed to violence, and may have been sustained as a result of an incomplete stress fracture instead.

The criteria for diagnosing a parry fracture should thus be: absence of radial involvement; a transverse fracture line; a location below midshaft; and either minor un-alignment in any plane, or horizontal apposition from the diaphysis (Judd 2008: 1661). The injury sustained by the male individual, Skeleton D from Hazleton North long barrow only conforms to one of the criteria given by Judd (2008: 1661). The fracture was sustained on the distal third of the diaphysis, but it was not possible to ascertain whether the fracture was transverse or oblique without using radiographs. There was a well-healed callus, but no sign of apposition or un-alignment. Furthermore, the corresponding radius has sustained a Colle's fracture, which is also well-healed. It is obviously not possible to ascertain whether both of these fractures occurred at the same time, but this individual was particularly susceptible to fracture due to the extremely gracile nature of the forearm, which may have been caused by disuse atrophy due to suspected poliomyelitis.

Therefore, using Judd's criteria (2008), this individual was unlikely to have suffered a parry fracture. The other individual, a probable male from Haddenham long barrow, also sustained a fracture in the distal third of the left ulna, but the fracture line is not visible macroscopically. The fracture is well healed, and the callus quite large, with a slight overlap in the horizontal plane. Unfortunately, the corresponding radius was not extant, thereby making a diagnosis of a parry fracture difficult using Judd's Criteria (2008). Smith and Brickley (2009: 128) report that an individual from Adlestrop long barrow had suffered a fracture to the ulna, which had not healed in alignment but had deviated laterally.

14.5.3 Lower Limb Fractures

Fibula

Four adults from three sites have evidence of well-healed fractures of the fibula. Two individuals (one unsexed adult and one possible female) had a fracture to the proximal end of the diaphysis, possibly caused by a blow to the side of the leg. An adult male from Hazleton North long barrow had a well-healed fracture to the distal end of the left fibula, which caused a rupture of the interosseous ligament. A further adult from Hazleton North long barrow (unsexed) suffered a fracture to the fibular neck and an avulsion fracture of the styloid process. The injury caused the articular surface of the head to remodel and flatten.

Lawrence (2012: 326) reports two injuries to the patellae of two individuals at Isbister, together with a greenstick fracture to the distal tibia which was probably inflicted during the growth years. Five cases of fractured metatarsals (three fifth metatarsals and two first metatarsals) are also reported, which Lawrence (2012: 332) considers to have been caused either by direct trauma, or fatigue due to repeated stress. There was one case of a healed oblique fracture to the right fibula from Ascott-under-Wychwood (Galer 2007: 202)

This study has therefore added six new cases of interpersonal violence in the Neolithic period to the archaeological record. One individual suffered a peri-mortem cranial fracture (Belas Knap CIV), and three others had healed evidence of depressed fractures to the frontal bone (Winterbourne Monkton EU.1.5.044, Randwick A3081B, and Wor Barrow # 8). Two individuals had healed injuries to the zygomatic bone (Belas Knap EU.1.5.04 and Hazleton North # 8754). The fact that these cases of violence are spread over a wide geographical area of southern Britain may indicate that this was not a local phenomenom but a facet of life at this time.

Chapter 15: Conclusions

The current study was carried out with the intention that any information gleaned would enrich the archaeological record on what is presently known about these prehistoric populations. The re-analysis aimed to assert that examination of “jumbled and scrappy” human remains (Beckett and Robb 2006: 57), which are unfortunately characteristic of the period, was justified and a worthwhile exercise. Furthermore, it was intended that a reappraisal would provide insights into Neolithic burial rites, demographic profiles, and the health and diet of the population. It was hoped that this information would develop an understanding of Neolithic belief sysytems, by revealing patterns in the selection criteria of who was deemed appropriate for inclusion in the burial monument.

The detailed analysis of over 36000 whole and fragmentary human bone fragments revealed a wealth of information on burial practices, health and diet, pathological conditions and trauma. These skeletal collections had been previously examined and published by other researchers (Rogers 1990; Smith and Brickley 2009; Smith 2014; Schulting and Wysocki 2005), however the majority of the evidence consists of entirely new findings which add substantially to the archaeological record.

The importance of re-analysing assemblages that have undergone previous evaluation has been highlighted by the examination of the assemblage from Hazleton North long barrow. This site comprised 2889 whole bones and 18676 fragmented bones, which with the benefit of three decades of research since the initial report, yielded evidence of hitherto unrecognised funerary behaviour at the site – scavenging by canids during the process of excarnation. The work by Binford (1981) and Haglund (1979), which focused on the damage to bone by scavenging animals, was in its infancy when the initial bone report was written by Rogers (1990), therefore evidence of this funerary practice was unrecognised. The re-analysis also presented a possible case of poliomyelitis and strongly affirmed the tentative diagnosis of a case of DISH by Rogers (1990), with new evidence of septic arthritis from the same individual. Additionally, the re-analysis found new or further evidence of metabolic disease, dental disease, joint disease, and trauma.

Forty-one sites included inhumation burials, but only one, Chestnuts long barrow, contained solely cremation burials. Seven of the 41 sites (17%) with inhumations also had token deposits of cremated material. It was evident from the weight of the deposits, that they did not represent a whole cremated corpse, but were placed perhaps as a representation of the deceased. It may be that both excarnation and cremation burials were more prevalent at long barrows in the Neolithic, but biased excavation and curation of the human remains may have led to the unfortunate situation where the evidence has been lost.

The demographic profiles obtained for the current study follow the pattern found by other researchers, in that the adult burials at sites are comprised of slightly more males than females (Smith and Brickley 2009:88). However, there was very low proportion of adolescent human remains at all sites (5%, 16/305) which may reflect differential funerary practices. However, the very young and children were present in significant numbers at two sites, where they represented 41% (17/41) and 38% (16/42) of the population at Hazleton North and West Kennet respectively. It was therefore apparent that the age and sex of the deceased was not the guiding criteria for inclusion within a long barrow in the Neolithic period.

The results from the current study and that of Lawrence (2012) at Isbister in Orkney would seem to suggest that metabolic disease was perhaps more prevalent than previously thought, although much of Lawrence’s evidence is unconvincing and his data difficult to decipher. Six infants and children under the age of eight years from three sites (Hazleton North, Belas Knap and Fromefield) exhibited signs of scurvy, and significantly, 67% (4/6) of those affected came from one site, Hazleton North long barrow. Furthermore, an infant from this site could only have been exhibiting signs of the disease if its mother was also suffering from the vitamin deficiency whilst pregnant. Therefore, five individuals (12%, 5/41) from one site had evidence of vitamin C deficiency, which is significant, especially in the light of new evidence from Neil *et al*. (2016) which asserts that the community were not completely sedentary but travelled some distance, thereby maximising their exposure to vitamin C rich resources.

The evidence of dental disease revealed 15 cases of caries, with males (2/585) and females (2/384) similarly affected (0.3% versus 0.5%) and a higher prevalence for calculus, suggesting a diet at this time that was heavily reliant on protein, with a lower component of carbohydrate and sugars. Faunal remains excavated from Neolithic sites indicate that domesticated species such as cattle, pigs, and sheep were predominantly exploited, but some wild species, such as red deer, roe deer and aurochs are also in evidence (Serjeantson 2011: 25). The evidence for periodontal disease was relatively low compared to other studies, but, as was to be expected, was related to increasing age.

Lawrence (2012) suggests that the high prevalence of periodontal disease at Isbister is related to scurvy, and it may be significant that 29% (5/17) of the cases of the disease from the present study were from Hazleton North long barrow. Overall, ante-mortem tooth loss affected 41 individuals (21.3%, 41/192), and females were found to have a much higher prevalence than males (9.5%, 65/684 versus 3%, 27/905 in males). Once more, Hazleton North long barrow had the highest prevalence of ante-mortem tooth loss, with 16.6% (75/450) of tooth sockets affected, and although the condition is related to age and a high degree of dental wear, perhaps the presence of scurvy at the site would have had an effect on the ability to retain teeth in swollen and bleeding gums.

Evidence of dental abscesses was found at 12 sites and affected 28 individuals. Males had a higher prevalence of abscesses at 1.4% (13/905) and females had a lower prevalence rate of 0.6% (4/684). Hazleton North long barrow had the highest prevalence of the disease with 39% (11/28) of dentitions affected and all of the adults with the condition also exhibited attrition of the dentition.

The evidence for infectious disease in the Neolithic period presented by the current study highlights the antiquity of some infectious diseases. Ten individuals, five of whom had chronic otitis media, and one of who had otitis media and suspected meningitis, plus another individual who likely was suffering from poliomyelitis, present evidence of serious ill-health in the past. Six cases of chronic otitis media were presented for the first time, filling a gap in the paleopathological record. Further investigation of the temporal bone using CT scans would likely identify additional cases. There were many more examples of porosity on the petrous temporal bone from sites other than those mentioned, but the porosity may have been caused by taphonomic processes rather than pathological ones. Females had a much higher prevalence of the condition than males. The TPR for the left petrous temporal was 6.3% (2/32) which was only evident in females. The TPR for the right side was 5.6% (2/26) in males and 10.3% (3/29) in females. Two of the females had bilateral otitis media (Lanhill EU.1.5.105 and Rodmarton # 80), perhaps reflecting cultural practices where the women were responsible for cooking and the tending of fires, maximising their exposure to smoke. Furthermore, the possible case of meningitis was exhibited in an adult male from Belas Knap long barrow (#6) who also had chronic otitis media, which was possibly a complication of the latter.

The male from Hazleton North long barrow who probably suffered from poliomyelitis survived for a prolonged time with the condition, and may have struggled with daily tasks with a paralysed right upper limb, and his ability to contribute to the community may have been compromised. It is possible that the male individual may have not been able to contribute much in the form of hard labour for building purposes, or for help with ploughing or hunting. His inclusion within the monument at Hazleton North suggests acceptance nevertheless, even more so, if the deformed spine and paralysed limb marked him out as "different", and therefore worthy of inclusion within the tomb.

Even though the evidence of infectious disease is scant for this period, the diseases that have been presented in this study are of significance, as the existence of these conditions so far back in human history proves that examination of partial skeletal material can provide valuable insights into health of past populations. The evidence for otitis media was derived from four different sites, but only one had partially complete skeletons (Lanhill long barrow). The other three sites consisted of only crania and mandibles (Belas Knap long barrow); 21 fragments and three whole elements, plus seven loose teeth (Bown Hill long barrow); and 42 fragments and 22 whole elements (Rodmarton long barrow). Nevertheless, macroscopic examination justified further investigation of new bone formation and porosity on petrous bones, confirming the existence of the disease. In fact, if the crania had been intact, evidence of the lesions would not have been apparent.

A minimum of 23 individuals had evidence of osteoarthritis (7.5%, 23/305), with the most people affected by osteoarthritis of the spine in the apophyseal joints (3%, 9/305). Eight males and one probable male and six females and one probable female were affected by osteoarthritis, and when the TPR was adjusted for sex, it was found that males had a higher prevalence of the disease than females, except in the hip, the TMJ (mandibular fossae only) and the sternoclavicular joint (manubrium).

Of the individuals affected by osteoarthritis, 2.3% (7/305) had the disease in more than one joint. Skeleton #2 from Hazleton North long barrow was the most severely affected individual, with osteoarthritis of the right hip, knee and foot and spine, making movement awkward and painful. However, another adult male from this site is likely to have suffered from several conditions at once. Not only does this individual have osteoarthritis of the spine, shoulder, sternoclavicular joint and wrist, he is considered to have suffered from DISH. This condition is strongly related to individuals who are overweight and suffer from diabetes (Rogers and Waldron 2001: 361). In addition, Skeleton A has ankylosis of two metatarsals, strongly suggestive of septic arthritis, (a condition previously unreported in the Neolithic period) which individuals with osteoarthritis and diabetes are particularly susceptible to (Kaandorp *et al*. 1995: 1819; Matthews *et al*. 2010: 847). This individual would also have had a noticeably different appearance, and would have no doubt endured joint pain.

The majority of the congenital and developmental defects presented in the current study were recorded in the axial skeleton and 26 individuals (8.5% of the assemblages) had one or more abnormality. Fourteen individuals had extra cranial ossicles, with females having a higher prevalence than males (11%, 1/9 versus 6.25%, 1/16 for males). The adult male from Gatcombe Lodge long barrow had a suite of minor abnormalities in the form of several non-metric traits, and defects of two developmental fields, suggesting that this individual may have suffered from an unidentified syndrome. This individual had five extra cranial ossicles and a retained metopic suture, which are field defects of the blastemal desmocranium, and a precondylar tubercle on the occipito-cervical border of the cranial base, which is a para-axial mesoderm developmental defect (Barnes 1994: 82). In addition, he suffered from severe dental erosion on the occlusal surfaces of the mandibular molars, likely due to gastroesophageal reflux disease. The lack of any post-cranial bones hampered any further investigation into a possible classification of the type of syndrome that this individual may have been affected by.

Five individuals in the current study had congenital and developmental disorders that would have had an aesthetic and physical impact upon the lives of the affected, and this may have been a factor in the decision to include them in the burial monuments. The young adult female from West Kennet long barrow (EU. 1.5.148) with scaphocephaly would have had a prominent forehead, and a long and narrow skull, which would have affected her appearance. In addition, she may have had mild mental and behavioural deficits (Graham and Sanchez-Lara 2016: 202), which may have marked her out as “different”.

The middle-aged adult male from Wor Barrow (Skeleton # 4) would also have had a noticeable and different appearance from others within the community. This individual probably suffered from congenital muscular torticollis and has a twisted cranial vault that favours the right side, which has also caused the cranial base to turn to the right, affecting the ramus of the mandible on this side. This prolonged muscular deformation has made the cranium and mandible tilt to one side, while lifting the chin on the opposite side and probably resulted in facial asymmetry, and a considerably diminished range of movement in the neck (Graham and Sanchez-Lara 2016: 148).

The two individuals from Hazleton North long barrow (# 7365) and Nympsfield long barrow (# 2020) suffering from Klippel-Feil Syndrome could also have had an unusual appearance in the form of a shortened neck, which allowed only restricted mobility due to the fusion of the second and third cervical vertebrae. Lastly, the adult male individual suffering from unilateral, asymmetrical sacralization of the fifth lumbar vertebra, Skeleton D from Hazleton North long barrow, may have had scoliosis of the lower spine due to fusion of the vertebra only on the left side, causing a twisted appearance. This deformity would have produced lower back pain and stiffness of movement, and considering that this individual also had a paralysed upper limb due to poliomyelitis, would have made him noticeable within the community.

There were six cases of benign neoplastic disease and one possible case of malignant cancer presented in the current study, representing 2.3% of the assemblage (7/305). One possible case of a benign chondroblastoma of the humerus from Hazleton North long barrow has added to the palaeopathological record for this period.

None of these conditions would have adversely affected these individuals, only causing mild symptoms. However, the one possible case of malignant metastatic cancer in a young child from Avenis long barrow is the first case to be reported for the Neolithic period, making it an important discovery. Even though the remains of this child were only represented by a few fragments of cranium, the evidence of lesions from metastatic cancer were very apparent and underline the importance of re-examining assemblages from this period, no matter how small or fragmentary.

Twenty-six fractures from ten different sites, which affected at least 19 individuals (6.2%, 19/305) were presented in the current study. Twelve of these fractures are considered to have been inflicted as a result of interpersonal violence. The possible female from Rodmarton with a cranial fracture may be the same individual who has a peri-mortem fracture of the humerus, therefore 11 individuals were probably victims of assault. It is apparent that males had sustained more injuries than females and when the TPRs are calculated by sex, this is confirmed. The TPR for the left parietal is 2.4% for females (1/41) and 4.1% for males (2/49), and the TPR for the right frontal is 2.6% for females (1/38) and 3.6% for males (2/55).

It is also clear that females and children were not spared from violence either, and in three cases, the injuries were fatal (an adult female from Belas Knap, EU.1.5.03; an adolescent/child from the same site, EU.1.5.09; and a probable female from Rodmarton long barrow, EU.1.5.069). The extent of the damage inflicted upon the child is especially shocking. A large circular hole, measuring at least 50mm supero-inferiorly and 40mm medio-laterally is evident on the right frontal, which must have been inflicted by a large mace-like object, attesting to the ruthlessness of warring parties, or perhaps domestic violence.

Four new cases of cranial trauma were presented, bringing the total to eight individuals who had suffered blows to the head as a probable result of violence. Four out of the five cases (80%) of the peri-mortem cranial trauma were inflicted on the left side of the skull, on the parietal bone. This may suggest that the majority of the attacks were carried out from behind by right-handed assailants. In contrast, all of the healed cranial trauma cases were inflicted upon the right side of the head on the frontal bone, suggesting face-to-face attacks.

The elderly female from Lanhill long barrow suffered a broken nasal bone, and a fracture to the orbital rim, which was probably delivered by a blow to the side of the nose. In addition, she also had a triple fracture of the right zygomatic arch. Considering that these types of injuries either occur as a result of assault, or in modern populations, from sporting injuries or car accidents (Tadj and Kimble 2003: 49), it can only be assumed that this individual was a victim of an assault, either on one occasion (as all of the fractures are well-healed), or at least twice. The other two individuals from Belas

Knap and Hazleton North who have also received blows to the face, resulting in a fractured zygomatic bone, are also likely victims of assault.

The current study has therefore added six new cases of interpersonal violence in the Neolithic period to the archaeological record. These new cases of violence are spread over a wide geographical area of southern Britain and show that this was not a local phenomenom but a facet of life at this time. Evidence of interpersonal violence from Isbister (Lawrence 2012) and elsewhere in Britain, such as Yorkshire, Wales and Ireland (Schulting 2012: 227; Smith 2014: 113) illustrates that the Neolithic was indeed a time of violence, but whether this was between competing groups or within the community cannot be proven. It does imply however, a growing tension and a willingness to perform acts of violence in a way that may not be evident in the preceding periods, maybe in a response to an increasing population, the challenge of animal husbandry and crop tending, and the associated problems of living in a confined area for long periods of time.

This extensive study has deciphered important new information about the people of the Neolithic period. By studying the human skeletal remains from 42 long barrows from southern Britain, it is clear that the degree of pathology, congenital and developmental disorders and trauma exhibited in the assemblage could not be considered to represent the average health of the population as a whole. Whether the individuals interred within the tombs were notable for their distinctive appearance, as some of those suffering from congenital disorders would have been, or whether they were distinct from others for having endured considerable pain (chronic or otherwise), it would seem that there was a selection bias in operation for those included in the distinctive burial monuments, maybe reflecting a complex belief system. It may be that those individuals who were able to withstand physical deformity, chronic illness, and broken bones were considered to be potent examples of strength under adversity, and therefore, who better to protect the living? Conversely, the inclusion of so many people suffering from these ailments could maybe indicate that they were viewed with horror, suspicion, and superstition by the community. By sealing the afflicted within the tomb, they were contained and unable to physically contaminate the community, and the periodical opening and sorting of the defleshed remains was a way to ensure that the occupants still remained. Maybe the dearth of burials from the Neolithic period can be explained by this phenomenom – only the seemingly *healthy* dead were deposited in the water, as they were not deemed to be a threat to the welfare of the community, thereby leaving ephemeral traces in the landscape.

There are yet future opportunities for exciting research to build on this addition to the academic record. Re-analysis of the collections that were not available for study at the Natural History Museum and those that went unexamined due to time constraints (Chapter 4) would augment the most up-to-date synthesis of the health, diet, funerary practices, demography, and evidence of interpersonal violence, which is presented in this thesis. Furthermore, undertaking a series of CT scans on the crania suspected of having otitis media would be useful to discover the extent of the condition in past populations. However, a methodology for exploring the diagnosis of otitis media in skeletal human remains using radiographs would also be beneficial, due the expense of CT scanning.

Appendix 1

The Neolithic long barrows of Hampshire were compiled using Winchester HER and Winchester UAD (2014), and *Long Barrows in Hampshire and The Isle of Wight* (RCHME 1979). Of the 41 barrows listed, five were associated with Neolithic human remains.

- Houghton Down.
- Giant's Grave (Old Winchester Hill).
- Moody's Down (S.E.).
- Portsdown.
- Nutbane.

The long barrows of Berkshire were compiled using West Berkshire HER (2014) and Berkshire archaeology HER (2014), and list four possible long barrows and two long barrows, only one of which contained human remains.

- Lambourn.

Buckinghamshire HER (2014) provided the information for the long barrows of that county, and listed four possible long barrows and one long barrow, which contained human remains.

- Whiteleaf Hill.

The long barrows in Sussex were compiled from the East Sussex HER (2014) and the West Sussex HER (2014), which listed four possible long barrows, seven Neolithic oval barrows, and five long barrows.

- Alfriston.

Fifteen possible long barrows and 26 long barrows were listed by Oxford HER (2014) and Oxford UAD (2014), three of which held human remains.

- Wayland's Smithy
- Moss Hill, Lambourn
- Ascott-under-Wychwood

The long barrows for Somerset were compiled by using the Bath and north-east Somerset HER (2014) and the Somerset HER (2014), which listed nine possible long barrows and 16 long barrows, seven of which held human remains.

- Orchardleigh Stones
- Priddy
- The Giants Grave
- Fromefield
- Braysdown
- Stoney Littleton
- Fairy's Toot

Surrey HER (2014) only lists one long barrow at Badshot Lea. The now quarried-out tomb has revealed some pottery sherds and flint, but no human remains.

Essex HER (2014) listed four possible long barrows, which were all ploughed-out and only remained as cropmarks. Not surprisingly, none of these contained any human remains.

The long barrows of Devon were compiled using Devon HER (2014) and Pastscape (2014). These sources listed three possible long barrows and eight long barrows, only one of which contained human remains.

- Broadsands

Kent HER (2014) listed eight possible long barrows and nine long barrows, two of which have yielded Neolithic human remains.

- Chestnuts
- Coldrum

The long barrows of Hertfordshire were compiled from the Hertfordshire HER and St Albans UAD (2014), which listed 13 possible long barrows and one long barrow. One of the possible long barrows contained one inhumation, and the long barrow held one inhumation and one cremation burial.

- Pirton
- Therfield Heath

Bedfordshire HER (2014) lists six possible long barrows, one of which contains human remains, and one Neolithic oval barrow.

- Shillington
- Bedford (Bunyan Centre)

The long barrows of Dorset were compiled using the Dorset HER (2014) and Grinsell's Dorset Barrows (1959 and 1982), which list 14 possible long barrows, 48 long barrows, and two Neolithic round barrows. Five of the long barrows and both of the round barrows contained human remains.

- Wor barrow
- Forty Acre
- Longbury
- Chettle
- Luton Down

The two Neolithic round barrows are situated either side of Wor Barrow, on Handley Down.

- Handley 26
- Handley 27

The long barrows of Gloucestershire were compiled using the Gloucestershire HER (2014), which listed 41 possible long barrows and 70 long barrows, of which, 32 contained Neolithic human remains.

- Belas Knap
- Notgrove
- Uley long barrow (Hetty Pegler's Tump)
- Nympsfield
- Adlestrop Hill
- Lamborough Banks
- Norn's Tump
- Gatcombe Lodge
- West Barrow (Boxwell with Leighterton)
- West Tump
- Pinkwell
- Coberley
- Crippets
- Cow Common Long, Swell
- Pole's wood South

- Pole’s Wood East
- Hazleton North
- Hoar Stone
- Camp Barrow North
- The Toots
- Bown Hill (Woodchester)
- Rodmarton (Windmill Tump)
- Willersey Hill Camp
- Randwick
- Sale’s Lot
- Jack Barrow
- Througham Field, Bisley-with Lypiatt
- Bisley-with-Lypiatt
- Avenis (Smart’s Farm)
- Eyford Hill
- Burn Ground
- Avening (Cherington)

The long barrows of Cornwall were compiled by the Cornwall and Scilly HER (2015), which listed six possible long barrows and two long barrows, together with 44 passage or chambered graves, which are the most common type of Neolithic monuments in Cornwall. None of the long barrows contained human remains from the Neolithic period but two of the chambered tombs did.

- Sperris Quoit
- Zennor Quoit

Wiltshire contains the greatest concentration of long barrows in Britain, consisting of 22 possible long barrows and 100 long barrows, 42 of which contain Neolithic human remains (Wiltshire HER, 2014).

- Fussell’s Lodge
- King Barrow, Boreham
- Netheravon 6
- Figheldean 31
- Amesbury 42

- Winterbourne Stoke 1
- Amesbury 14
- Wilsford 30
- Winterbourne Stoke 35a
- Giants Grave/Milton Lilbourne (Fyfield)
- Fittleton 5
- West Kennett
- Temple Bottom
- Wanborough/Liddington
- Shalborne 5a (Smay Down)
- Lugbury (Littleton Drew)
- Lanhill
- Giant’s Cave (Luckington)
- Stockton
- Knook 5
- Bowls Barrow (Heytesbury 1)
- Norton Bavant
- Warminster
- Knook
- Corton
- Heytesbury 4
- Easton Down
- Tilshead 7
- Tilshead Down (Old Ditch)
- Tilshead Lodge
- Tilshead 1 (Kill Barrow)
- Winterbourne Stoke 53
- Winterbourne Monkton (Cist Burials)
- Horton Down (Bishops Cannings 91)
- Oldbury Hill
- Kings Play Down (Heddington 3)
- Shepherds Shore

- Arn Hill (Warminster 1)
- Millbarrow
- Chute
- Tinhead
- Bratton
- Silver (Orcheston 4)

The long barrows of Lincolnshire were compiled using the records held at North Lincolnshire Her (2015) and Lincolnshire Her (2015), which noted 36 possible long barrows, 16 probable long barrows, and 41 long barrows, three of which contained human remains.

- Spellow Hills
- Giant's Hills I, Skendleby
- Giant's Hills II, Skendleby

Derbyshire HER (2015) lists seven long barrows, four containing human remains

- Gospel Hillocks
- Ox Low
- Long Dale
- Rockhurst

Herefordshire HER (2015) lists five possible long barrows and two long barrows, none of which have been excavated.

Leicestershire HER (2015) and Shropshire HER note no record of any long barrows in their databases.

Staffordshire HER (2015) notes two long barrows, only one containing human remains.

- Longlow, Wetton

Warwickshire HER (2015), Cheshire HER (2015) and Suffolk HER (2015) did not list any long barrows but noted two, two and eight possible long barrows respectively.

Norfolk HER (2015) lists 74 possible long barrows and five long barrows, one of which contained human remains.

- Broome Heath, Ditchingham

Lastly, Cambridgeshire HER (2015) lists six possible long barrows, and eight long barrows, of which three contained human remains.

- Haddenham, Fowlmere Fen
- Haddenham, Lower Delphs
- Eynesbury, Barford Road

Appendix 2

Site and Date Cal. BC	County	Burial Type	# of Indivs	Excavation Date and (Reference)	Location of Collection	Date Access Requested	Date Analysed	Why not analysed?
Houghton Down	Hants	?	?	Lost				lost
Giants Grave	Hants	?	?	Unofficial disturbance				unofficial
Moody's Down	Hants	Inhumation	1	1940 (Grimes, 1960)				unlocated
Portsdown	Hants	Inhumations	12	Unofficial, 1816				unofficial
Nutbane	Hants	Inhumations	4	1957 (Morgan, 1959)	Andover Museum & Winchester	June 2014		Time constraint
Lambourn 3760-3645	Berks	Inhumations	2	1964 (Wymer, 1965/6)	Reading Museum	Sep 2014		Time constraint
Whiteleaf Hill	Bucks	Inhumation	1	1930s (Gordon Childe & Smith, 1955)	Bucks Museum, Aylesbury	Sep 2014		Time constraint
Alfriston	Sussex	Inhumation	1	1974 (Drewett, 1975)				unlocated
Wayland's Smithy **3610-3550**	Oxon	Inhumations	22	1919/20 Peers & Smith: 1962/3 Atkinson & Piggott (Peers & Smith, 1921: Atkinson, 1965)	Reading Museum Natural History Museum	Sep 2014 Feb 2014		No access
Moss Hill, Lambourn	Oxon	Inhumations	4	Atkins, 1852 (Case, 1950)				unlocated
Ascott-under-Wychwood **3750-3690**	Oxon	Inhumations Cremation	21	Benson, 1960s (Benson & Whittle, 2006)				Recent report
Orchardleigh Stones	Smset	Inhumations Cremations	?	In antiquity & St George Gray, 1920 (St George Gray, 1921)				unlocated
Priddy	Smset	Inhumations Cremations	?	Bristol University Spelaeological Society, 1928 (Phillips & Taylor, 1972).				lost
Giant's Grave	Smset	Inhumations	5	Skinner, 1826; Wickham, 1909 (Skinner *et al*. 1971: Wickham, 1918)				lost
Fromefield	Smset	Inhumations	15	Vatcher & Vatcher, 1965 (Vatcher & Vatcher, 1973)	Taunton Museum	June 2014	March 2016	
Braysdown	Smset	Inhumations Cremations	3+	Skinner, 1815 (Skinner, *et al*. 1971)				unlocated
Stoney Littleton	Smset	Inhumations	16	Skinner & Colt Hoare, 1816: Thomas, 1999/2000 (Colt Hoare, 1821: Thomas, 2003)	Taunton Museum	June 2014	March 2016	

Fairy's Toot (Nempnett Thrubwell)	Smset	Inhumations	9+	Bere, 1793: Skinner *et al.*, 1971				lost
Broadsands	Devon	Inhumations	4	1958 Ralegh Radford (Ralegh Radford, 1958)	Torquay Museum	Oct 2014	October 2015	
Chestnuts	Kent	Cremations	9	1957, Alexander (Barfield, 1961)	Maidstone Museum	Dec 2014	April 2015	
Coldrum **3980-3800**	Kent	Inhumations	17	Bennett, 1910 (Bennett, 1913)	Duckworth Laboratory Natural History Museum	Jan 2014 Feb 2014		No access
Therfield Heath	Herts	Inhumation Cremation	2	Nunn, 1855; Phillips, 1935 (Phillips, 1935)				unlocated
Pirton	Herts	Inhumation	1	?				unlocated
Shillington	Beds	Inhumation	1	(same site as above – straddles border)				unlocated
Bedford (Bunyan Centre)	Beds	Inhumation	1	1998, Bedfordshire Archaeology (1999, Steadman)				unlocated
Wor Barrow **3695-3635**	Dorset	Inhumations	6	Pitt Rivers, 1894 (Pitt Rivers, 1898)	Salisbury Museum	Feb 2014	May 2015	
Forty Acre	Dorset	Fragmentary HR	?	Cunnington, 1881 (Acland, 1916).				unlocated
Longbury	Dorset	Inhumations	?	1802, 1855, 1950s Unknown (Ross, 1988)				unlocated
Chettle	Dorset	Inhumations	?	18th Countess Temple (Warne, 1866)				unlocated
Luton Down	Dorset	Fragmentary HR	?	Cunnington, 1896 (Richardson, 1897)				unlocated
Handley 26	Dorset	Inhumations	2	Colt Hoare, 1805; Pitt Rivers 1894 (Colt Hoare, 1812; Pitt Rivers, 1898)	Salisbury Museum	Feb 2014	May 2015	
Handley 27 **3310-2910**	Dorset	Fragmentary HR	?	Colt Hoare, 1805; Pitt Rivers 1894 (Colt Hoare, 1812; Pitt Rivers, 1898)	Salisbury Museum	Feb 2014	May 2015	
Belas Knap	Glos	Inhumations	36+	Winterbotham and Lawrence, 1863-1865; Aston, 1870s?; 1929/30 Ministry of Works (Lawrence, 1866; Berry, 1929; Hemp, 1929)	Duckworth Laboratory Cheltenham Museum	Jan 2014 Jan 2014	June 2015 July 2015	
Notgrove	Glos	Inhumations	2 +?	Witts, 1881; Clifford,	Cheltenham	Jan 2015		Recent report

3510-3330				1934/5 (Witts, 1912; Clifford, 1936)				
Uley (Hetty Pegler's Tump)	Glos	Inhumations	24+	Fry & Lloyd Baker 1821, Thurnam, 1854 (Maclean, 1880; Thurnam 1854; Clifford, 1966	Exeter University Duckworth Laboratory	 Jan 2014	July 2015 Dec 2015	
Nympsfield	Glos	Inhumations	16+	Buckman, 1862; Clifford, 1937; Saville, 1979 (Buckman, 1865; Clifford, 1938; Saville, 1979)	Exeter University Stroud Museum Duckworth Laboratory	 Jan 2015 Jan 2014	July 2015 July 2015 June 2015	
Adlestrop Hill **3980-3690**	Glos	Inhumations	10	Freer, 1935; Donovan, 1938 (Donovan, 1938)	Stroud Museum	Jan 2015		Recent report
Lamborough Banks	Glos	Inhumation	1	Lysons, 1854 (Lysons, 1865)	Duckworth Laboratory	Jan 2014	Dec 2015	
Norn's Tump	Glos	Inhumation	1	Not excavated (Avening 3 stones from here?)	Unofficial			unofficial
Gatcombe Lodge	Glos	Inhumations	2	Lysons, 1870 (Crawford, 1925)	Duckworth Laboratory	Jan 2014	June 2015	
West Barrow (Boxwell with Leighterton)	Glos	Inhumations Cremations	?	Huntley c1700 (Witts, 1883)				unlocated
West Tump **3770-3090** **3630-3370**	Glos	Inhumations	20	Witts, 1880 (Witts, 1880)	Natural History Museum Stroud Museum (scant)	Feb 2014 Jan 2015	 July 2015	No access
Pinkwell	Glos	Inhumations	3	Akerman, 1856 (Akerman, 1859)				unlocated
Coberley	Glos	Inhumation	1	Bird, 1865 (Bird, 1877)				unlocated
Crippets	Glos	Inhumation	1	c 1779 (?)				unlocated
Cow Common Long, Swell	Glos	Inhumations	11	Royce, 1867/8; Greenwell & Rolleston, 1874 (Greenwell & Rolleston, 1877; Maclean, 1880)	Natural History Museum	Feb 2014		No access
Pole's Wood South	Glos	Inhumations	12	Greenwell & Rolleston, 1874 (Greenwell & Rolleston, 1877)	Natural History Museum	Feb 2014		No access
Pole's Wood East	Glos	Inhumations	19	Greenwell & Rolleston, 1874 (Greenwell & Rolleston, 1877)	Natural History Museum	Feb 2014		No access

Hazleton North **3730-3655**	Glos	Inhumations	33	Saville, 1979/82 (Rogers, 1990)	Cirencester Museum	Feb 2014	May-Sept 2016	
Cherington (Avening)	Glos			Thornbury, 1806 (Clifford & Daniel, 1940)	Stroud Museum	Jan 2015	June 2015	
Hoar Stone	Glos	Inhumations	8/9	Freston, 1806 (Freston, 1812)				Unlocated
Camp Barrow North	Glos	Inhumations	?	No record				unrecorded
The Toots	Glos	Inhumation?	1?	Never excavated but a skeleton and a stone exhibited in 1880 said to be from here				unofficial
Bown Hill (Wood-chester)	Glos	Inhumations	6	Paine & Witchell, 1863 (Paine & Witchell, 1865)	Duckworth Laboratory	Jan 2014	June 2015	
Rodmarton (Windmill Tump)	Glos	Inhumations	13 + fragm ents	Lysons, 1863; Clifford, 1939 (Lysons, 1863; Clifford & Daniel, 1940)	Duckworth Laboratory British Museum Natural History Museum	Jan 2014 Feb 2014	June 2015	 No access
Willersey Hill Camp	Glos	Fragmentary HR	?	Witts, 1884 (Witts, 1884)				unlocated
Randwick	Glos	Inhumations	7	Witts & Witchell, 1883 (Witts, 1884)	Exeter University		July 2015	
Sale's Lot **3910-3020**	Glos	Inhumations	18	O'Neil, 1963/5 (O'Neil, 1965)	Bournemouth University	Jan 2015		Recent report
Jack Barrow	Glos	Inhumations	?	Unknown, 1874; Clifford, 1937 (Clifford, 1937)	Stroud Museum	Jan 2015	June 2015	
Througham Field, Bisley-with-Lypiatt	Glos	Inhumation	1	Disturbed by workmen, 1833 (Witts, 1883)				unofficial
Bisley-with-Lypiatt	Glos	Inhumation	3	Paine & Bird, 1863 (Paine, 1912)				unlocated
Avenis, Bisley (Smart's Farm)	Glos	Inhumation Cremation	3	Paine, 1865 – 1876 (Jowett Burton, 1925)	Stroud Museum	Jan 2015	June 2015	
Eyford Hill (Upper Slaughter)	Glos	Inhumations	20	Royce, Rolleston, & Greenwell, 1874 (Greenwell & Rolleston, 1877)				unlocated
Burn Ground **3950-3630**	Glos	Inhumations	15	Grimes, 1940/1 (Grimes, 1960)	Bournemouth University	Jan 2015		Recent report
Sperris Quoit	Cnwall	Cremation (scant)	?	Noall, 1910 (Thomas & Wailes, 1967)	Penlee Museum, Penzance	Sept 2014	Sept 2014	
Zennor Quoit	Cnwall	Cremation (scant)	?	Thomas & Wailes, 1954 (Thomas & Wailes, 1967)	Penlee Museum, Penzance	Sept 2014		lost

Fussell's Lodge 3700-3630	Wilts	Inhumations Cremations	53 - 57	Ashbee, 1957 (Brothwell & Blake, 1966)	Natural History Museum	Feb 2014		No access
King Barrow, Boreham	Wilts	Cremation	1	Colt Hoare & Cunnington, 1806 (Colt Hoare, 1812)				Re-buried?
Netheravon 6	Wilts	Inhumations	2	Thurnam, 1863 (Thurnam, 1869)	Duckworth Laboratory	Jan 2014	June 2015	
Figheldean 31	Wilts	Inhumation	1	Thurnam, 1863 (Thurnam, 1869)	Duckworth Laboratory	Jan 2014	June 2015	
Amesbury 42	Wilts	Inhumations	2	Thurnam, 1865 (Thurnam, 1869)				unlocated
Winterbourne Stoke 1	Wilts	Inhumation	1	Thurnam, 1863 (Thurnam, 1869)	Stonehenge Visitor Centre	April 2015		on display
Amesbury 14 (Stonehenge)	Wilts	Inhumations	3	Colt Hoare & Cunnington, 1804; Thurnam, 1865 (colt Hoare, 1812; Thurnam, 1869)	Duckworth Laboratory	Jan 2014	June 2015	
Wilsford 30	Wilts	Inhumations	4	Colt Hoare & Cunnington, 1803 (Colt Hoare, 1812)				Re-buried?
Winterbourne Stoke 35a	Wilts	Inhumation	1	Thurnam, 1864 (Thurnam, 1869)				unlocated
Giants Grave (Fyfield)	Wilts	Inhumations	3/4	Thurnam, 1865 (Thurnam, 1869)	Duckworth Laboratory	Jan 2014	June 2015	
Fittleton 5	Wilts	Inhumations	?	Cunnington, 1851; Thurnam, 1860 (Cunnington, 1895; Thurnam, 1869)	Duckworth Laboratory	Jan 2014	June 2015	
West Kennet 3729-3674	Wilts	Inhumations Cremations	54	Thurnam, 1859: Piggott & Atkinson, 1955/6 (Thurnam, 1860; Piggott, 1962)	Duckworth Laboratory Devizes Museum	Jan 2014	Dec 2015 Jan 2017	
Temple Bottom	Wilts	Inhumation Cremation	2+	Lukis & Smith, 1861 (Lukis, 1867)				unlocated
Wanborough (Liddington)	Wilts	Inhumations	4	Disturbed by workmen c1890 (Passmore, 1922)				unofficial
Shalborne 5a (Smay Down)	Wilts	Inhumations	?	Unofficial excavation, (Cunnington, 1914)				unofficial
Lugbury (Littleton Drew)	Wilts	Inhumations	26	Colt Hoare, 1821; Scrope, 1854 (Colt	Duckworth Laboratory	Jan 2014	Oct 2015	

				Hoare, 1822; Thurnam, 1857a)				
Lanhill	Wilts	Inhumations	22+	Thurnam, 1855; Cunnington, 1909; Keiller & Piggott, 1938 (Thurnam, 1875b; Cunnington, 1909b; Keiller & Piggott, 1938)	Duckworth Laboratory Natural History Museum Devizes Museum	Jan 2014 Feb 2014 Jan 2014	Dec 2015	 No access
Giant's Cave (Luckington)	Wilts	Inhumations Cremations	25	Passmore, 1932; Corcoran, 1960/1 (Passmore, 1934; Corcoran, 1970)	Duckworth Laboratory	Jan 2014	Dec 2015	
Stockton	Wilts	Inhumations	4	Colt Hoare & Cunnington 1810 (Colt Hoare, 1812)				Re-buried?
Knook 5	Wilts	Inhumations	4+	Cunnington, 1801/2 (Colt Hoare, 1812)				Re-buried?
Imber/Bowls Barrow (Heytesbury 1)	Wilts	Inhumations	14	Colt Hoare & Cunnington 1800, 1803; Thurnam, 1864; W & H Cunnington, 1885/6 (Colt Hoare, 1812; Thurnam, 1869; Cunnington, 1889)	Duckworth Laboratory Devizes Museum	Jan 2014 Jan 2014	Dec 2015	
Norton Bavant	Wilts	Inhumations	18	Thurnam, 1865 (Thurnam, 1869)	Duckworth Laboratory Natural History Museum	Jan 2014 Feb 2014	Oct 2015	 No access
Warminster 6	Wilts	Inhumation	1	Colt Hoare & Cunnington, 1806; Thurnam, 1865 (Colt Hoare, 1812; Thurnam, 1869)				unlocated
Knook	Wilts	Cremations	7/8	Colt Hoare & Cunnington, 1801; Thurnam, 1866 (Colt Hoare, 1812; Thurnam, 1869)				unlocated
Corton	Wilts	Inhumations	8	Colt Hoare & Cunnington, 1804 (Colt Hoare, 1812)				Re-buried?
Heytesbury 4	Wilts	Inhumations	?	Cunnington, 1800 (Colt Hoare, 1812)				Re-buried?
Easton Down (Bishops Cannings	Wilts	Inhumations	4	Thurnam, 1860 (Thurnam, 1869)				lost

65)								
Tilshead 7 (East)	Wilts	Inhumations	8	Thurnam, 1863 (Thurnam, 1869)	Duckworth Laboratory	Jan 2014	Oct 2015	
Tilshead Down (Old Ditch)	Wilts	Inhumations Cremations	3+	Colt Hoare & Cunnington, 1802; Thurnam, 1865 (Colt Hoare, 1812; Thurnam, 1869)	Duckworth Laboratory	Jan 2014	Oct 2015	
Tilshead Lodge	Wilts	Inhumations	2	Colt Hoare & Cunnington, 1802; Thurnam, 1865 (Colt Hoare, 1812; Thurnam, 1869)	Duckworth Laboratory	Jan 2014	Oct 2015	
Tilshead 1 (Kill Barrow)	Wilts	Cremation	1	Thurnam, 1865 (Thurnam, 1869)				unlocated
Winterbourne Stoke 53	Wilts	Cremation	1	Colt Hoare & Cunnington, 1806 (Colt Hoare, 1812)				Re-buried?
Winterbourne Monkton	Wilts	Inhumations	31	Hillier, 1854 (Hillier, 1854)	Duckworth Laboratory	Jan 2014	Oct 2015	
Horton Down (Bishops Cannings 91)	Wilts	Inhumations	?	Thurnam, 1863 (Thurnam, 1869)	Duckworth Laboratory	Jan 2014	Dec 2015	
Oldbury Hill	Wilts	Inhumations	3	Cunnington, 1864 (Cunnington, 1864)	Devizes Museum Duckworth Laboratory	Jan 2014 Jan 2014	May 2015 June 2015	
Kings Play Down (Heddington 3)	Wilts	Inhumation	1	Cunnington & Cunnington, 1907 (Cunnington, 1909a)	Devizes Museum	Jan 2014	May 2015	
Shepherds Shore	Wilts	Inhumations Cremation	5	Cunnington, 1927 (Cunnington, 1927)				unlocated
Arn Hill (Warminster 1)	Wilts	Inhumations	3	Colt Hoare & Cunnington 1806 (Colt Hoare, 1812)				Re-buried?
Millbarrow	Wilts	Inhumations	13	Thurnam, 1863; Whittle, 1989 (Thurnam, 1869; Whittle, 1994)	Devizes Museum	Jan 2014	Sep 2015	
Chute	Wilts	Inhumations	?	Passmore, 1934 (Passmore, 1942)				unlocated
Tinhead	Wilts	Inhumations	?	Thurnam, 1865 (Thurnam, 1869)				unlocated
Bratton	Wilts	Cremations	1/2	Colt Hoare & Cunnington, 1804; Thurnam, 1866 (Colt Hoare, 1812;	Devizes Museum British Museum	Jan 2014 Jan 2014	May 2015	

				Thurnam, 1869)				
Silver (Orcheston 4)	Wilts	Inhumations	7	Tucker & Bartlett, 1801 (Colt Hoare, 1812)				Re-buried?
Winterbourne Monkton	Wilts	Inhumations	31	Hillier 1854 Davis & Thurnam 1865	Duckworth Laboratory	Jan 2014	Oct 2015	
Giants Hills I (Skendleby I)	Lincs	Inhumations	9+	Phillips, 1933/4 (Cave, 1935)	Duckworth Laboratory	Jan 2014	Oct 2015	
Giants Hills II (Skendleby II)	Lincs	Inhumations	2	Evans & Simpson, 1975/6 (Harman, 1991)				unlocated
Gospel Hillocks	Derbys	Inhumation	3	Lukis, 1865 (Lukis, 1867/8)				unlocated
Ox Low	Derbys	Inhumation	1	Tym, c1870 (Pennington, 1877)				unlocated
Long Dale (Smerrill Moor)	Derbys	Inhumations	12	Bateman, 1857 (Bateman, 1861)	Sheffield Museum (2)	Feb 2015		Time constraint
Rockhurst	Derbys	Cremation	1	Bateman, 1849 (Bateman, 1861)				unlocated
Long Low	Staffs	Inhumations	13	Carrington, 1849 (Bateman, 1861)	Sheffield Museum (2)	Feb 2015		Time constraint
Broome Heath	Norfolk	Inhumation	1	19th century, unrecorded				unofficial
Haddenham, Fowlmere Fen	Cambs	Inhumations	7	Hodder, 1985/7 (Lee, 2006)	Cambs Archaeology Unit	March 2015	April 2016	
Haddenham, Lower Delphs	Cambs	Inhumation	1	(Silvester, 1985)	Cambs Archaeology Unit	March 2015		Time constraint
Barford Rd., Eynesbury	Cambs	Human Remains	?	Wessex Archaeology, 2001/2 (Ellis, 2004)	Cambridge County Council	March 2015		Time constraint

Appendix 3

Bones with evidence of gnawing by animals from Hazleton North long barrow.

Individual or #	Chamber	Element	Side	Age
Skeleton A	North	Humerus	Left	Adult
Skeleton A	North	Tibia	Left	Adult
Skeleton A	North	Fibula	Left	Adult
Skeleton C	North	Humerus	Left & Right	Adult
Skeleton C	North	Radius	Left	Adult
Skeleton C	North	Ulna	Left & Right	Adult
Skeleton C	North	Femur	Left & Right	Adult
Skeleton C	North	Tibia	Left & Right	Adult
Skeleton C	North	Fibula	Left & Right	Adult
Skeleton C	North	Calcaneus	Left	Adult
Skeleton C	North	Metatarsal 3	Left	Adult
Skeleton C	North	Metatarsal 4	Left	Adult
Skeleton C	North	Metatarsal 5	Left	Adult
Skeleton G	North	Fibula	Left	Child
Skeleton G	North	Humerus	Left & Right	Child
Skeleton H	North	Tibia	Right	Child
Skeleton H	North	Radius	Right	Child
Skeleton H	North	Fibula	Right	Child
# 5091	North	Fibula	Unsided diaphysis	Adult
# 5770	North	Pedal phalanx	Unsided	Adult
# 6108	North	Rib 1st	Left	Adult
# 5487	North	Femur	Right	Adult
# 5874	North	Femur	Left	Adult
# 8818	North	Femur	Right	Adult
# 8816	North	Femur	Right	Adult
# 4735	North	Femur	Left	Adult
# 5090	North	Tibia	Left	Adult
# 5094	North	Tibia	Right	Adult
# 5883	North	Tibia	Right	Adult
# 5508	North	Tibia	Right	Infant
# 5484	North	Tibia	Left?	Infant
# 9847	North	Tibia	Unsided diaphysis	Adult
# 5531	North	Fibula	Left	Adult

# 10389	North	Fibula	Left	Infant
# 4747	North	Fibula	Left	Adult
# 6491	North	Fibula	Right	Adult
# 6086	North	T vertebra		Adult
# 5099	North	Rib	Left	Adult
# 6483	North	Rib	Right	Adult
# 6489	North	Rib	Right	Adult
# 6183	North	Clavicle	Left	Adult
# 5898	North	Clavicle	Right	Adult
# 5514	North	Clavicle (fragment)	Unsided	Adult
# 5471	North	Clavicle (fragment)	Unsided	Adult
# 5906	North	Rib (fragment)	Unsided	Adult
# 6210	North	Metacarpal 4	Left	Adult
# 8391	North	Metacarpal 3	Right	Adult
# 8906	North	Rib	Right	Adult
# 9061	North	Mandible		Adult
# 9060	North	Manual Phalanx	Unsided	Adult
# 9689	North	Metatarsal 4	Right	Adult
# 4805	South	Rib (fragment)	Unsided	Adult
# 10499	South	Clavicle	Left	Adult
# 10484	South	Fibula	Right	Adult
# 11438	South	Tibia	Right	Child
# 8662	South	Tibia	Left	Adult

Appendix 4

Estimations of stature from measurements of the femur.

Site	Sex	Side	Length mm	Stature cm	Femoral head mm
Giant's Hills EU.1.5.114	M	L	443	167	46
Giant's Hills EU.1.5.115	F	L	387.5	150	37.6
Giant's Hills EU.1.5.115	F	R	391	150	36.4
Giant's Hills EU.1.5.116	F	R	399	153	37.5
Handley 27	M	L	485.5	176	51.3
Handley 27	M	R	482	176	53.2
Hazleton North # 5037-32	M	R	431	164	45.9
Hazleton North # 5037-29	M	L	436	165	45.9
Hazleton North # 6203	F	R	422	158	42.2
Hazleton North # 7655	M	L	461	171	43.5
Hazleton North # 7465	M	R	455	170	44.3
Hazleton North # 4183	M	L	423	162	45.1
Hazleton North #4184	M	R	424	162	45.9
Hazleton North # 7837	M?	L	433	161-164	Eroded
Hazleton North # 7835	M	R	432	164	45.3
Hazleton North #4787	M	L	458	170	45
Hazleton North # 6810	M	R	455	170	45.1
Hazleton North # 11035	F	L	429	160	41.1
Hazleton North # 9554	F	R	429	160	41.5
Hazleton North # 8663	F	L	401	153	40.1
Hazleton North # 9990	F	R	392	151	40.6
Kings Playdown	M	L	435	165	45.5
Kings Playdown	M	R	434	165	46.2
Lanhill EU.1.5.105	F	L	438	162	42.1
Lanhill EU.1.5.105	F	R	435	162	42.5
Lanhill EU.1.5.106	F	L	442	163	42.5
Lanhill EU.1.5.107	F	L	386	149	38.6
Lanhill EU.1.5.107	F	R	384	149	38.6
Lanhill EU.1.5.108	M	L	482	173	43.2
Lanhill EU.1.5.108	M	R	474	171	42.2
Lanhill EU.1.5.109	M	L	404	158	41.9
Lanhill EU.1.5.109	M	R	408	159	41.6
Luckington GC/D/1	F	L	396	152	37.3

West Kennet EU.1.5.140	M	R	460	171	43.7
West Kennet NE chamber	M?	R	438	162-165	43.7
West Kennet SW chamber	F	L	380	148	39.7
West Kennet SW chamber	F	R	417	157	43.5
West Kennet Skeleton IX?	F	R	399	153	42
West Kennet SW chamber	F	R	438	162	37.2
West Kennet NW chamber	F	L	439	162	42.8
West Kennet NE chamber	F?	L	404	154	Eroded
West Kennet NE chamber	F	L	441	163	42.9
Wor Barrow # 1	F?	L	413.5	156	42.8
Wor Barrow # 1	F?	R	409.5	155	42.6
Wor Barrow # 2	F?	L	453.5	166	42.6
Wor Barrow # 2	F?	R	449	165	43.4
Wor Barrow # 3	M	L	421	161	Eroded
Wor Barrow # 3	M	R	420	161	46.1
Wor Barrow # 4	M	L	469	173	44
Wor Barrow # 4	M	R	474	174	44.5
Wor Barrow # 5	F?	L	406	154	40.7
Wor Barrow # 6	M	R	406	158	44.2
Wor Barrow # 8	M	L	461	171	46.3
Wor Barrow # 8	M	R	466	172	47

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